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THE GLACIERS AND GLACIATION OF ALASKA[1]

INTRODUCTION

Notwithstanding the great area of Alaska, the ruggedness and inaccessibility of a large part of the glaciated region, and the briefness of the period of exploration, we are already in possession of a large body of fact with regard to the glaciers and glaciation of our northern territory. The researches of Wright,[2] Russell,[3] Reid,[4] Gilbert,[5] Davidson,[6] Dall[7] and others have given us much valuable information concerning the coastal region; and the many expeditions by Hayes,[8] Brooks, and various other members of the United States Geological Survey[9] have added ma-

[1] Presidential address before the Association of American Geographers, at the Washington meeting, December 29, 1911.

[2] Wright, G. F., "The Ice Age in North America," New York, 1891, chapter III., pp. 36–66.

[3] Russell, I. C., "An Expedition to Mount St. Elias, Alaska," *Nat. Geog. Mag.*, Vol. 3, 1891, pp. 53–203; "Second Expedition to Mount St. Elias," Thirteenth Ann. Rept. U. S. Geol. Survey, pt. 2, 1892, pp. 1–91.

[4] Reid, H. F., "Studies of Muir Glacier, Alaska," *Nat. Geog. Mag.*, Vol. 4, 1892, pp. 19–84; "Glacier Bay and its Glaciers," Sixteenth Ann. Rept. U. S. Geol. Survey, pt. 1, 1894–95, pp. 415–461.

[5] Gilbert, G. K., "Glaciers and Glaciation," Harriman Alaska Expedition, Vol. III., New York, 1904.

[6] Davidson, G., "The Glaciers of Alaska," Trans. and Proc. Geog. Soc. Pacific, Vol. III., Ser. II., June, 1904, 98 pp.

[7] Dall, W. H., U. S. Coast Pilot, Pacific Coast, Part I., Alaska, 1883, Washington, D. C.

[8] "An Expedition through the Yukon District," *Nat. Geog. Mag.*, Vol. 4, 1892, pp. 117–159.

[9] Mainly published in annual reports, bulletins and professional papers of the U. S. Geological Survey.

terially to this knowledge, and have extended the area of observation to the interior. Thus, even though there is yet much to learn, the knowledge that we now possess is sufficient to warrant a discussion of the general phenomena of Alaskan glaciation; and since this is the object that has been most in my mind during the past six years, it has naturally appealed to me as the most fitting topic for the presidential address which I am called upon to give.[10]

THE EXISTING GLACIERS

Condition of the Existing Glaciers

Alaskan glaciation is, and has been, of the mountain type. That is to say, mountain snow fields have shed into mountain valleys, and through these the glacier ice has flowed to lower levels, in some cases even to the sea. Numerous glaciers, and in former times a still greater number, have flowed beyond their valleys and spread out fan-shaped at the mountain base, giving rise to the type of *piedmont* glacier which Russell has made known to us through his studies of the Malaspina glacier.

The main region of existing glaciers occupies a roughly semicircular area sweeping from the southern boundary of Alaska, northward, westward and southwestward, toward the Aleutian islands. From either end of this zone both the number and the size of the glaciers increase, and the elevation of their termini decreases, attaining maximum development near the center of the semicircle that surrounds the head of the Gulf of Alaska. Altogether there are at least 47 tidal glaciers in this zone, the southeasternmost being the Le Conte Glacier, just north of Wrangell, and the westernmost McCarty Glacier on Kenai peninsula. Toward the ends of the glacier zone there are few and scattered instances of tidal glaciers; but in the central part of the zone they are numerous, and, where topographic conditions favor, are close together. Thus in Glacier Bay there are at least twelve tidal glaciers; in Yakutat Bay three; and in Prince William Sound twenty.

How many glaciers there are in this coastal area can not be even approximately estimated; but, counting large and small, tributaries and main ice streams, they are certainly to be numbered by the thousand. These vary in size from tiny ice masses in cirques, to valley glaciers two or three miles in breadth and thirty or forty miles in length; and up to the great Malaspina Glacier whose area is estimated to be 1,500 square miles. From the Kenai peninsula to Cross Sound a very large proportion of the seaward face of the mountains is covered with snow and ice, and glaciers exist in a majority of the valleys, deeply filling most of the larger ones. From Controller Bay to Cross Sound a succession of piedmont glaciers and expanded bulbs of individual glaciers spread out between the mountain base and the sea. A journey along this coast is, therefore, a constant glacial panorama.

Distribution of Existing Glaciers

The mountains which fringe the Alaskan coast as a continuous barrier, as far west

[10] The personal field work upon which this address is in part based was done in 1905 and 1906 under the auspices of the U. S. Geological Society; and in 1909 and 1911 under the auspices of the Research Committee of the National Geographic Society. To both of these bodies acknowledgments are due for the generous financial support given. The last two expeditions have been under the joint leadership of Professor Lawrence Martin and myself; and I wish especially to acknowledge my indebtedness to my colleague in two seasons of work, who was also an assistant on the first expedition. We have worked and observed together and have freely discussed all problems which have arisen. The results of our joint work are used in this address, as are also the results of other students of Alaskan glaciation.

as Cook Inlet, attain their greatest elevation in the St. Elias-Fairweather Range where peaks rise 12,000 to 15,000 feet, 18,000 feet in Mount St. Elias, and 19,540 feet in Mount Logan. Here, naturally, the glaciers are largest, for from this central area the general elevation, as well as the heights of the peaks, diminishes toward both the southeast and the west.

Back from the coast, and roughly parallel to the curving mountain barrier around the head of the Gulf of Alaska, is another lofty range sweeping northward from the Alaska peninsula, then eastward and southeastward. In its highest part, called the Alaska Range, are numerous lofty mountain peaks, including Mount McKinley (20,300 feet), the highest mountain in North America. Between this interior range and the coastal mountains is a broad depression occupied by Cook Inlet in the south and the Copper River Basin in the east; but in the extreme east the area between the two mountain ranges is mainly occupied by the great volcanic group known as the Wrangell mountains, whose peaks attain elevations of from 14,000 to 16,000 feet.

Naturally these lofty mountains of the interior are also the seat of numerous and large glaciers. But neither here, nor on the inner face of the coastal mountains, is there so full a development of ice and snow as along the coast. The snow line is higher, the glacier ends are all necessarily well above sea level, and the piedmont type of glacier is absent. The glaciers are essentially confined to the mountain valleys, though some extend to the mouths of the valleys, and a few spread slightly beyond them. It must not be inferred that the glaciers of the interior are insignificant either in size or in number; merely that they suffer in comparison with their larger neighbors nearer the sea. Were they the only glaciers of Alaska they would themselves attract wide attention because of their number and size. Besides being dwarfed by comparison with the coastal glaciers, these in the interior have the disadvantage of remoteness and relative inaccessibility. They are, therefore, far less well known than the glaciers of the coast.

The difference between the glaciers on the two sides of the coastal mountains may be typically illustrated by the Valdez-Klutena system, two glaciers which descend in opposite directions from a common divide in the Chugach mountains, at an elevation of 4,800 feet. The Valdez Glacier, descending on the seaward side of the mountains, is 19 miles long and ends at an elevation of 210 feet, while the Klutena Glacier, descending toward the interior, is only 6 miles long and ends at an elevation of 2,000 feet. A similar difference is observed in the Nizina and Chisana glaciers, which descend from a common divide at an elevation of 8,000 feet in the Wrangell Mountains, the former descending on the side facing the sea and therefore being much longer than the Chisana Glacier, which flows toward the interior. The total length of the two ice streams is about 47 miles.

Beyond the Alaska Range, although there are numerous mountain and plateau areas of considerable elevation, lying far to the north, there is a general absence of existing glaciers, the only exception, so far as known, being on the Arctic slope of the Endicott Mountains (5,000–8,000 feet). Here, in the summer of 1911, Phillip S. Smith and A. C. Maddren[11] observed a number of small valley glaciers.

Explanation of the Distribution of the Glaciers

The distribution of glaciers in Alaska is not difficult to explain. That they are so

[11] Personal communications to the author.

extensively developed along the seaward face of the coastal ranges is plainly due to the fact that the prevailing winds are from the ocean, and that in blowing over the warmed waters of the Gulf of Alaska a large amount of vapor is moved forward and precipitated in the form of snow upon the lofty mountain barrier. It is where the coastal barrier is most complete and highest that the snowfall is heaviest and the development of glaciers greatest. The annual precipitation varies greatly, records of from 100 to 190 inches having been obtained at stations along this coast; but there is no knowledge as to the precipitation among the lofty mountains, excepting the knowledge that it is very heavy and mainly in the form of snow.

In a region where from 10 to 40 feet of snow falls each year at sea level, there must be exceedingly heavy snowfall at elevations where the precipitation is all in the form of snow. As an indication of the vast snowfall among the mountains, reference may be made to Schrader's observation of from 8 to 12 feet of snowfall on Valdez Glacier during a week late in April and early in May, 1898. By such heavy precipitation the snowline is depressed to levels of 2,500 to 3,500 feet on the seaward face of the mountains, and to even lower levels back in the mountains where the local climate is cooled by the chill of the surrounding areas of snow and ice.

Since the damp winds precipitate so much vapor in crossing the mountain barrier, there is a deficiency for precipitation on the inner slopes of the mountains and on the ranges further inland. Moreover, such winds as sweep into interior Alaska from either the Arctic Ocean or Bering Sea bear but a limited vapor burden, since the water of these seas is cold in summer and more or less completely ice-covered in winter. Records at Eagle give a rainfall of only 11.35 inches; but the precipitation is doubtless higher toward the west and in the lofty mountains.

The winters of the interior are prevailingly clear and cold with moderate snowfall—for example, only 2 or 3 feet of snow falls in the Copper River Basin; but in spring and summer the temperature is so high that the snow quickly melts even well up on the mountain slopes. Thus, even in the neighborhood of the Arctic Circle a plateau from 3,000 to 6,000 feet in elevation is completely free from snow in summer, as is also a large portion of the Endicott mountains; and, whereas the snowline on the seaward face of the St. Elias range is about 3,000 feet, it is more than twice as high as that in the interior three or four hundred miles further north. The exact elevation of the snowline in the interior can not be stated, and indeed it must vary greatly from place to place. In general, however, it is above 6,000 feet.[12]

This rise in the snowline toward the north is interesting as showing how important the element of precipitation is. The snowline is lower and the glaciers are larger where the mean annual temperature is high and the precipitation is heavy, than in the much colder climate further north where, however, precipitation is light and the short summers are warm. A similar variation is noticed in the coastal mountains where the snowline is considerably higher along the inner fiords than on the outer coast where the precipitation is heavier. It is to be noted, however, that in the latter place not only is there a greater depth of snow to be melted, but in the neighboring lofty mountains there are

[12] Oscar Rohn (Twenty-first Annual Report U. S. Geological Survey, pt. 2, 1899–1900, p. 413) states that on September 1 the snowline was 7,500 feet in one part of the Wrangell Mountains, and was then descending.

broad expanses of snow and ice which serve to retard summer melting.

In the distribution of its glaciers Alaska presents a striking contrast to that part of Europe in the same latitude. There are no glaciers in southern Scandinavia, in the latitude where, in Alaska, the glaciers are largest; and while in Norway there is an increase in glaciation northward, in Alaska there is a decrease. In Norway the influence of latitude is permitted to exert its normal effect; but in Alaska the influence of latitude is effectually counterbalanced by variations in topography and in the vapor content of the air. This contrast may have some significance in the explanation of the development of extensive ice sheets in northwestern Europe and northeastern America, while northern Asia and northwestern North America, in the same latitude, were free from continental glaciation.

Ice Flooded Valleys and Through Glacier Systems

Only by individual description of a large series of instances would it be possible to adequately portray the varied characteristics of the Alaskan glaciers. As in the Alps, Caucasus and Himalayas, the valley glacier is the normal type, but with many variations in form, size and rate of motion. From the lofty peaks a series of radiating glaciers usually spread outward; but throughout much of the mountain area there is a complex of ramifying glacier systems. Nowhere, so far as known, is there a development of the ice cap condition such as is found in Norway, Spitzbergen and Iceland, for the mountains are so lofty and rugged that the valley slopes serve to drain away the surplus snow that falls upon the steep mountainsides.

Still the snowfall is so heavy, especially near the coast, that, in the process of drainage, the valley systems are deeply filled with ice in spite of the ruggedness and high elevation. In the area of greatest glacier development, in the St. Elias region, the extent of snow and ice is so great as to have led Russell to speak of it as "a vast snow-covered region, limitless in expanse, through which hundreds and perhaps thousands of barren, angular mountain peaks projected," and to compare it to the "borders of the great Greenland ice sheet." How deeply these vast glacier systems fill the valleys we have no means of telling; nor can we even estimate the aggregate length or area of the maze of ice streams that flood the mountain valleys. In a region where dozens of glaciers are known to have lengths of from twenty-five to forty miles, it can not be doubted that the aggregate length of the ice streams is thousands of miles, and that the total area of snow and ice amounts to tens of thousands of square miles.

Although the vast bulk of ice that is slowly draining away the snow that falls among the Alaskan mountains maintains the valley glacier condition rather than developing an ice cap, it gives rise to an intermediate condition, as Russell's description intimates. That is, although the mountain summits are not flooded, the valleys are. For example, one may start from Yakutat Bay and, traveling up one of the large glaciers, rise above the snowline by a moderate grade and finally reach a flat, snow-covered divide, beyond which, also with moderate grade, a descent leads down a glacier flowing in the opposite direction. Or, to the right or the left, also over flat, snow-covered divides, an easy route is open down other glaciers. In this way one may travel for scores of miles, going from one valley to another and from one glacier to another, but crossing only broad, flat snow divides. So deeply is the region submerged

by ice that both the valley bottom topography and the valley head divides are so smoothed out as to give rise to a continuous, connected glacier system with drainage in different directions from flattish divides; but both the divides and the glacier distributaries from them are walled in by steeply rising mountains, each portion of the system having the characteristics of the valley glacier. For such a complex I have proposed the name—*through glacier system.*

The through glacier condition is rendered possible by presence of low divides, and it is believed that, in general, these have originated during an earlier period of more intense glaciation when the snow and ice accumulated to much greater depths than now and flowed across the divides, lowering them by glacial erosion.

In its main essential characteristics, even the through glacier system belongs in the class of valley glaciers; and the valley glacier phenomena in Alaska are in the main the same as those with which we are already thoroughly familiar from the studies of glaciers in the Alps, Himalayas and other mountain regions. As compared with those of the Alps, the larger valley glaciers of Alaska are far greater, and this naturally introduces corresponding differences in form and behavior; but these are differences in detail rather than in underlying principles, and may therefore be dismissed in the present discussion.

At their termini some of the Alaskan glaciers present features not found in the Alps, notably the termination in tidal cliffs from which icebergs are discharged, and expansion on the land to form piedmont bulbs and piedmont glaciers. At a period of former expansion of glaciers, the piedmont condition was present in the Alps also; and the present Alaskan glaciers are more comparable with those expanded Alpine glaciers than with their shrunken descendants of to-day.

Development of the Cascading Glacier

As in other mountain regions, the present-day Alaskan glaciers, though very large, are mere remnants of a former far greater system, occupying the lower levels of valleys which were profoundly deepened by erosion when the former greater ice masses occupied them. Accordingly, the surface of the present-day glaciers, in the main valleys, is very often well below the level of the surface of the tributaries, which therefore descend with steep slope at their lower ends. There is every gradation, from the accordant junction of tributary and main glaciers, to the ice step, or "bench," where the two join; to the cascading descent of the tributary as it joins the main ice stream; and to the former tributary, now cut off from junction with the main glacier, but cascading toward it in its lower portion where it passes out of its hanging valley and descends the steepened valley slopes in a series of broken steps like a great frozen waterfall. This condition is so well developed in Alaska, and is so widespread and so characteristic, both in form and cause, that the descriptive name *cascading glacier* has been proposed for it.

Development of the Ablation Moraine

Glacial erosion, which has produced extraordinary topographic change in the Alaskan mountains, has, among other results, given rise to very steep valley walls. Such steep slopes, produced by ice erosion during the higher stage of the glaciers, are now, on exposure to the air, in a state of instability under the attacks of the agents of subaerial denudation. Therefore, they weather rapidly, and from them rock falls and avalanches frequently descend. This

rock, mixed in the snow out of which the glacier is made, and spread out over its surface, is concentrated by ablation in the dissipator until the ice surface often becomes completely covered by a sheet of moraine, to which the name *ablation moraine* has been given. It is naturally upon the lower ends of the glaciers that the ablation moraine is most extensively developed; but in some instances it extends far up the valleys, almost or quite to the snowline. Then the valley glacier looks so little like an ice stream that it may not be recognized as one by the casual observer; and on some of the Alaskan maps such glaciers have found no place.

Since only a portion of the Alaskan glaciers bear ablation moraine it is evident that special conditions are demanded for its development. It is best developed on those ice tongues with steep walls and steep heads, whose width is not too great for avalanches to spread out well toward the middle, and whose valley walls are of a friable rock. In proportion as these conditions vary, the extent of the moraine sheet also varies. Normal weathering and the spread of the falling rock through the snow fields and over the ice tongues are undoubtedly sufficient to account for the formation of a sheet of ablation moraine; but the excessive development of such moraine in some portions of the Alaskan region may perhaps be due in part to the aid which earthquake shaking gives in the downthrow of avalanches from the glacier valley walls. When a glacier bearing a sheet of ablation moraine has melted away, it leaves not only a deposit of till with scratched stones, but overlying this a sheet of coarse, angular fragments and weathered materials. Such deposits are to be expected in mountain regions of former glaciation.

Influences Modifying Rate of Recession of Glaciers

The ablation moraine is one of the factors influencing the position and rate of recession of glacier fronts; another factor is the position of the front, whether on the land or in the sea; for in the latter case recession is far more rapid and active than in glaciers ending on the land. For example, in the St. Elias region, while the Guyot, Seward, Marvine, Lucia, Yakutat and other glaciers that end on the land have spread out from one to twenty miles beyond the mountain front, the great, rapidly-moving tidal Hubbard Glacier, near by, ends at the head of Disenchantment Bay, ten miles or more back among the mountains. Both tidal and non-tidal glaciers are exposed to surface wastage by melting and evaporation; but the tidal glaciers are further exposed to the effective attack of the salt water which quickly removes the ice fragments that fall into it. Therefore, other things being equal, the tidal glacier will naturally terminate farther back among the mountains than non-tidal glaciers of similar character.

Glaciers advancing into rivers are also actively attacked, as is illustrated by the Childs and Miles glaciers in the Copper River Valley, and by glaciers in the Alsek Valley. To a lesser degree the same tendency to more rapid retreat is present in glaciers that terminate in lakes, as the Yakutat Glacier does.

Among ice tongues ending on the land there is great difference in the rate of wastage according to exposure and elevation; but even more important is the protective influence of the cover of ablation moraine. This finds best illustration in those glaciers which spread out fan-shaped at the mountain base, attaining a state of stagnation or semi-stagnation along their margins. Here, near sea level, in a rainy,

temperate climate, wastage by ablation would normally be active, and if the ice supply failed the glaciers would rapidly recede. But the sheet of ablation moraine that develops serves as a blanket against both melting and evaporation, and the rate of wastage so decreases with increase in thickness of the morainic cover that there finally comes a condition of almost complete protection. When the moraine cover is no longer subject to frequent undermining and slumping, vegetation finds a foothold, and ultimately even a mature forest may spread over the moraine that blankets the ice. Glacier recession under such conditions almost ceases and an ice terminus may remain for scores of years without notable change, even though ice supply is completely cut off.

In view of the fact that a protected ice terminus may remain so long in one position, it follows that the piedmont condition is not necessarily proof either of recent expansion or of a continuance of ice supply after expansion. Indeed, there is reason to believe that the piedmont glaciers, and the piedmont bulbs of individual glaciers in Alaska have been formed by expansion at entirely different periods. In some the supply is still being maintained and the ice terminus is kept in place by the essential balance between supply and wastage. This seems clearly to be the case in the greater part of the Malaspina Glacier; but elsewhere there is evidence that the expansion occurred during an earlier period of advance, and that the ice supply has long since been withheld. This is true of the piedmont bulbs of Galiano and Lucia glaciers, to the ends of which the effects of even a recent notable advance did not extend. In still other cases, the ends of the bulbs have become almost or even completely separated from the main glacier by wastage of clear ice areas back of the terminus. The piedmont bulb develops during a period of advance; it may linger, in more or less mutilated condition, through a period of stagnation, receiving redevelopment when next an advance of sufficient volume occurs. In other words, it does not necessarily represent an existing state of activity and supply; for, because of the protection of a blanket of ablation moraine, it may long retain its position even in the face of warmth, abundant rainfall and failure of ice supply.

Marginal and Terminal Deposits

Since on the seaward side of the coastal mountains, the ends of so many large glaciers lie in a temperate, rainy climate, the phenomena of terminal and marginal deposit are illustrated with great clearness, throwing much light on the origin of similar phenomena in the deposits of former continental glaciers. Particularly is this true of the piedmont areas, not only because of the wide extent of their margins, but also because they are existing examples of a type of glacier that was formerly common in the mountain regions of both Europe and America. It can not be made a part of this address to consider this subject in detail, interesting and important thought it is.[13] Suffice it to say that in Alaska one may see in process of development both lateral and terminal moraines in great variety of form and composition, from stratified gravel or sand, or clay, to true till; eskers and kames; outwash gravel plains and kettles of various forms and sizes; lacustrine deposits of many kinds and marginal lakes of various origins; marginal channels due to erosion

[13] See Tarr, R. S., "Some Phenomena of the Glacier Margins in the Yakutat Bay Region, Alaska," *Zeitschr. für Gletscherkunde*, Vol. 3, 1908, pp. 81–110; also, "The Yakutat Bay Region, Alaska," U. S. Geol. Survey, Professional Paper 64, 1909.

and the work of marginal streams in deposit; indeed almost the whole series of phenomena which were present along the receding margins of the Pleistocene glaciers. There are phenomena of recession, of advance, and of alternate recession and advance in the course of which soil beds and plant remains were incorporated between distinct sheets of glacial deposits.

Of all the deposits at present being made in association with Alaskan glaciers, those made by the glacial streams are by far the most prominent. During the summer, torrents of water issue from the margins of the glaciers, and, where the ice is stagnant or thin enough for the existence of subglacial tunnels, from the central portions also. These torrents, doubtless esker-building beneath the glacier, spread out over alluvial fans, or broad outwash gravel plains, or long, narrow valley trains, which they are upbuilding by the extensive deposition that is made necessary by the overburdened condition of the streams on their escape from the ice tunnels. Over such a deposit the streams spread in a multitude of anastomosing branches, ever shifting in position as they aggrade their beds in the effort to establish a grade sufficient for the transportation of the sediment load. Within a few miles of the glacier front the slope of the aggrading streams may average 50 or 60 feet to the mile, and close by the glacier even much more than this.

So great is the velocity of the glacial torrents that good-sized stones are dragged along, and one can hear them striking together as they roll on down stream. First the boulders are dropped, then the gravel, then the sand, and with the change in material deposited is an associated change in grade; but throughout their course the grade of the glacial streams is commonly very steep, for they are normally so charged with sediment, and much of the sediment is so coarse, that it quickly settles in a slow current. Schrader says that in its upper course the Klutena River has a grade of 60 feet a mile, then for 28 miles an average grade of 22 feet a mile and a velocity of 14 miles an hour. The Copper River, into which it empties, flows with a velocity of 8 miles an hour.

The Sediment Supply of the Glacial Streams

In volume, slope and sediment load the Alaskan glacier streams are noteworthy. During a period of a few months each year the drainage of a wide area, locked up in the form of snow and ice, is turned into torrents of running water which issue as full-fledged streams, and even as veritable rivers from near the glacier ends. A glacier that is just at the balance between supply and melting furnishes to the streams only that water which is brought down to or near to the ice front; but in a glacier that is receding, there is added to this supply all that which is melted from the ice that is no longer moving forward. Therefore, where, as is so often the case in Alaska, the glaciers are stagnant or receding, the supply of water exceeds the normal.

The impressive volume of sediment, fine and coarse, which the glacial streams are transporting leads the inquiring mind to raise the question as to its origin. Streams having their source in the rainfall are not often so sediment-laden as the glacial streams normally are; indeed, even the exceptional land-supplied streams are rarely as heavily burdened, even for a few days, as the glacial torrents normally are for several months. Particularly is the question of the origin of the finer grained sediment of interest. It is abnormal in quantity as compared with mountain streams in gen-

eral, and yet it comes from a drainage area largely protected by snow and ice against those atmospheric agencies which transform hard rock to fine clay. Can there be any doubt but that the glacier which protects the rock against the atmospheric agencies must attack it with equal or even greater vigor, in order to obtain this vast burden of sediment that the streams bear away?[14]

The Recession of Glaciers in Alaska

Throughout the world the general state of the glaciers is one of recession, with local exceptions; and it is as true of Alaska as of other regions. In the two regions where we have the longest record and the most detailed studies—Glacier Bay and Yakutat Bay—there have been great recessions during the period of observation, the continuation of a still greater earlier recession during the last century or more. For instance, in Yakutat Bay the tidal Nunatak Glacier receded at the rate of over 1,000 feet a year between 1899 and 1906, with a total recession of over a mile; and the nearby Hidden Glacier, ending on the land, receded at about a quarter of this rate. Prior to this observed recession, both Hidden and Nunatak glaciers had been so far advanced that they united and their combined front reached about 20 miles farther out than the present end of Nunatak Glacier, and 10 miles beyond the present terminus of Hidden Glacier. From this advanced position there has been rapid and long-continued recession which was in progress up to 1906 in Hidden Glacier, and up to 1909 in Nunatak Glacier. If the observed rate of recent recession of Nunatak Glacier has been steadily maintained throughout the period, it is to be reckoned as of about a century duration.

[14] See von Engeln, O. D., *Zeitschrift für Gletscherkunde*, Band VI., 1911, pp. 138–144.

In Glacier Bay the phenomena have been closely like those of Yakutat Bay. A long-continued recession had been in progress when the Muir Glacier was studied by Wright in 1886, and by Reid in 1891 and 1892, when Muir Glacier front was about 20 miles further inland than it had been 100 or 150 years before; and Grand Pacific Glacier front was about twice that distance back of the former terminus. Where ice had formerly filled the mountain-walled valley to a depth of 3,000 feet, the fiord waters extended in 1892. This recession has continued since then, being especially noteworthy since 1899; and now (1911) both the Grand Pacific and the Muir Glacier fronts are 9 or 10 miles farther back than in 1892, the average recession being at a rate of not far from 2,500 feet a year for the 19 years; but it is to be noted that the rate has not been regular, and that the greater part of the recession has occurred since 1899. The retreat has continued up to 1911 in all the glaciers of Glacier Bay with the single exception of Rendu Glacier (and a small cascading glacier near it), which has recently advanced about a mile and a half. Glacier Bay has been enlarged no less than 50 square miles by ice recession in a period of 19 years. Assuming an average thickness of 750 to 1,000 feet, the total loss of ice in this period is not less than 6 or 8 cubic miles. But to this must be added that which has been lost by ablation from above the present ice surface; and this is also an enormous amount, for all the outer glacier surfaces, even far back from their fronts, are now much lower than they were in 1892.

While these instances are the most striking of which there are records in Alaska, in our own studies Professor Martin and I have observed scores of other cases, widely separated, where there has been notable recent recession and where it is still in prog-

ress; and many instances have been made known to us by the observations of other workers. Therefore, the commonly accepted conclusion that recession is the general rule among the Alaskan glaciers is fully warranted; yet the rule is by no means invariable. For example, Columbia Glacier began advancing in 1908, and Professor Martin found it still advancing in 1910, while in the same year he observed commencement of advance of several glaciers of different sizes in Prince William Sound and Copper River valley. We know also of recent advance of other Alaskan glaciers, the total known to us to have advanced since 1899 being 43, nine of which are in Yakutat Bay; but some of these 43 advances are exceedingly slight; and 43 glaciers form but a minute proportion of the whole number of Alaskan glaciers. These facts demonstrate that it can not be assumed either that the recession is universal, or that it is not liable to interruption. Too little is known about Alaskan glacier history and about Alaskan climate and its variations to warrant any generalization with regard to the possible future of its glaciers; it is not even certain that the present state of general recession is anything more than an episode.

Advance of Glaciers as a Result of Earthquake Shaking

Of all the recent glacier advances of which we have record in Alaska, by far the most interesting are those of Yakutat Bay. Following the vigorous earthquakes of September, 1899, and, as I have elsewhere endeavored to show,[15] as an indirect result of them has come a series of forward movements and transformations of a very spectacular character, interrupting a period of general recession and affecting even stagnant glaciers and piedmont bulbs. First there came a spasmodic advance of at least two small glaciers, and probably others that we failed to detect on our first expedition in 1905; then, in the interval between September, 1905, and June, 1906, an advance occurred in four larger glaciers; in 1906 and 1907 the Hidden Glacier advanced; in 1909 the still larger Lucia Glacier; and in 1909–10 the Nunatak Glacier advanced. The progressive appearance of the advance, correlated with the length of the glaciers, has been set forth in the following table prepared by Professor Martin:

Name of Glacier	Date of Advance	Approximate Length of of Glacier
Galiano	After 1895 and before 1905	2 or 3 miles
Unnamed Glacier	1901	3 or 4 miles
Haenke	1905–6	6 or 7 miles
Atrevida	1905–6	8 miles
Variegated	1905–6	10 miles
Marvine	1905–6	10 miles (exclusive of portion in Malaspina piedmont area)
Hidden	1906 or 1907	16 or 17 miles
Lucia	1909	17 or 18 miles
Nunatak	1910	20 miles

The advance involved a profound breaking of the glacier surface even where pre-

[15] I have presented this theory in various publications, and in these have given a full statement of the facts and a discussion of their bearing on the theory; so that, in view of the character of this address and its necessary briefness, only a very short and general statement is attempted. See especially Tarr, R. S., "Second Expedition to Yakutat Bay, Alaska," *Bull. Geog. Soc. Philadelphia*, Vol. 5, 1907, pp. 1–14; "Recent Advance of Glaciers in the Yakutat Bay Region, Alaska," *Bull. Geol. Soc. America*, Vol. 18, 1907, pp. 257–286; "The Yakutat Bay Region, Alaska," Professional Paper No. 64, U. S. Geol. Survey, 1909; "The Theory of Advance of Glaciers in Response to Earthquake Shaking," *Zeitschrift für Gletscherkunde*, Vol. 5, 1910, pp. 1–35; also Tarr, R. S., and Martin, Lawrence, "Recent Changes of Level in the Yakutat Bay Region, Alaska," *Bull. Geol. Soc. America*, Vol. 17, 1906, pp. 29–64; "The Yakutat Bay Earthquakes of September, 1899," Professional Paper No. 69, U. S. Geol. Survey, 1912 (in press).

viously smooth and uncrevassed; the lower portion of the glacier was greatly thickened; where unconfined between mountain walls there was a notable spreading at the margins; and the free ends of the glaciers were bodily moved forward. In all cases the transformation was rapid and even spasmodic, requiring a period of but a few months for the complete cycle; and in all cases the advance was quickly followed by relapse into the previous state. In other words, a wave spread down through the glaciers with accompanying thickening, spreading, advance and breaking of the rigid upper ice; but after passage the glacier was left in essentially the same state of activity as before, even though that state had been complete stagnation in parts of the affected area.

In some cases the wave spent its effects in breaking, thickening and spreading a piedmont bulb, with little actual advance; in others, the effects of the thrust being confined by bordering mountain walls, and thereby concentrated on the frontal end, there was notable advance of the terminus. Such an advance is best illustrated in the Hidden Glacier, whose front was pushed forward about two miles; and where the ice front stood in 1906 the glacier was 1,100 feet thick after the advance. During a brief, spasmodic advance, at least a third of a cubic mile of ice moved beyond the 1906 front; and great volumes of ice were also added to the glacier back of the old front, for in 1909 the glacier surface rose to a far greater height than in 1905 and 1906.

The theory put forward to account for this series of glacier advances is that the vigorous earthquakes of September, 1899 shook down such great avalances of snow, ice and rock in the glacier reservoirs as to necessitate a wave of advance that swept down through the glaciers, reaching the terminus of the smaller ice tongues very quickly, and the larger ones at later dates, while up to the period of our last observations, in 1910, the very largest glaciers had not yet responded. Since the cause was a sudden and concentrated addition of large supplies to the glacier reservoirs, the resulting wave was naturally rapid in its passage, and it quickly subsided, while its effects in passing were both spasmodic and extreme.

A study of four seasons discovers only evidence favoring this theory, and since it is an efficient cause, known to have been actually present, while no facts are known to oppose it and a great number favor it, I feel convinced that the earthquake avalanche theory merits the wide acceptance that it has received. It adds a new, and, in favorable regions, probably a very important cause for fluctuations in glacier margins. How widely it may be extended in explanation of other glacier advances remains to be established by future studies; it is not to be expected that it will replace the theory of climatic cause for glacier fluctuations; but it may well be expected to supplement it and perhaps in part replace it in regions of frequent earthquakes.

Local Nature of Recent Great Advances

It is too early to attempt to explain all the known variations in Alaskan glaciers, for as yet the body of fact is limited both as to time and as to area. Yet there are some significant features that are well worthy of consideration. Attention has already been directed to the fact that there has been a very great recent recession of the ice fronts in Glacier Bay and a similar recession in the Yakutat Bay region 150 miles to the northwest. This recession, which has been in progress for the past century or more, is really but part of a cycle in which the glaciers are still receding toward

a former minimum. Having at an earlier period been far advanced, and having held this position for a long time, the glaciers in both regions receded to a stand even farther back than the present ice fronts, and remained there long enough to permit the growth of mature forest; then came an advance pushing the ice fronts forward from 20 to 50 miles. This advance is known to have been of brief duration, for the gravels over which the glaciers advanced were not removed by the ice erosion; and it was quickly succeeded by the rapid recession that has been in progress during most of the period of observation.

So great an advance, followed by so great a recession, might be expected to be part of a general cycle affecting all or a large part of the Alaskan field. Yet such is not the case, for in Prince William Sound, 250 to 300 miles to the west of Yakutat Bay, the recent glacier history has been wholly different. In no case have the glaciers recently had a position far beyond their present fronts, while in some cases it is certain that they are to-day as far out as they have been in a century or two. This is especially clearly seen to be the case in Columbia Glacier, which in 1909 and 1910 was advancing into and destroying a mature forest. Forest also grows on the mountain slopes above the glacier for many miles back from its front, suggesting that this glacier is now in a state of unusual advance analogous to that experienced a century or more ago by glaciers to the southeast. Since there is no reason to suspect that a *general* cause which was operating to bring about glacier advance in the Alaskan coastal region could suffer retardation of a full century in the Prince William Sound region, we are forced to the alternate view that even such great advances and recessions as those proved for the Yakutat and Glacier Bay regions are localized phenomena. Whether due to uplift or depression, to vigorous and repeated earthquake shakings, or to local climatic variations remains yet to be determined.

Cause of the Recent Retreat of Muir Glacier

It has been a generally favorite theory that the remarkable recession of Muir Glacier since 1899 is an indirect result of the great earthquakes of September, 1899. Latterly it has been proposed that the recession is due not to this cause, but to the enlargement of ice area exposed to the sea water and consequently to wastage by iceberg discharge. Neither of these theories, nor the two combined, are either competent or needed to explain the phenomena of recession, though doubtless each has been a factor in it. Granting the maximum disturbance by earthquake shaking, and granting even that the glacier could be broken from surface to bottom, which is highly improbable in view of the nature of ice under pressure, the cracks would certainly heal and the ice become welded in its lower portions soon after the breaking. There would be no basis for the continuation of the effect of the earthquakes for a number of years after the shocks themselves had died out; yet recession has continued for twelve years after the earthquakes. Moreover, recession began many years before the earthquakes, though the rate has been much increased since 1899. As to the theory that the recession is due to the enlarged area of ice exposed to salt water, that is surely an efficient aid in recession; but it does not account for the continuation of notable recession of other glaciers in the region which now have less, rather than greater, area exposed to the salt water. Nor does it account for the excessive wastage along land margins and on ice surfaces back from the fronts.

In view of the fact that the glaciers of Yakutat and Glacier bays have been in a state of rapid recession for a century or more, all that is necessary in explanation of the recession since 1899 is to consider it an accelerated part of this grand retreat which must be due to a deficiency of snow supply following an excess in supply, or an emptying of the glacier reservoirs succeeding a filling of them. Of course, the rate of recession may readily have been temporarily modified by crevassing due to earthquake shaking, or locally modified by variation in exposure to wastage, or checked or increased by variations in precipitation or temperature. These, or any other temporary or local causes, are but minor episodes in the general withdrawal of glaciers which a century or two ago had, for some reason as yet unknown, been made to advance farther than they could maintain their fronts.

Some of the Factors Involved in the Phenomena of Advance and Retreat

Under the simplest of circumstances the advance or retreat of a series of glaciers is a complex phenomenon in which so many factors are involved that a full analysis of them can not be undertaken here. Yet some of the factors stand out with such distinctness that I may take time to briefly point them out. The nature of the glacier terminus is of fundamental importance. If the end of an ice tongue is in water it makes a great difference in the rate both of advance and recession whether the water is salt or fresh, whether it is deep or shallow, whether it is in active movement or is quiet, whether there is or is not a free escape for the icebergs, and whether the relative area of ice cliff is small or great. All these factors are effective in addition to the rate of supply of ice to be discharged. If, on the other hand, the terminus is on the land, there are influences of exposure, of elevation, and of amount of moraine cover, as well as the amount of ice supplied.

Illustration from Yakutat Bay

It is clear that there must be a very great difference, especially in recession, according to whether the ice front is on the land or in the sea, for in the latter position wastage is far more rapid than in the former. This finds clear illustration in the Yakutat Bay region, for during the recent great expansion of the glaciers, a century or more ago, not only were the tidal Nunatak, Turner and Hubbard glaciers caused to advance, but the glaciers ending on the land also pushed forward, presumably at about the same time. Along the margin of Malaspina Glacier, for instance, the same phenomena of overridden gravels and buried forests are discovered as in the area over which Nunatak-Hidden Glacier advanced. But while the tidal glaciers have receded 10 to 20 miles, the recession of Malaspina Glacier has been, at the most, but a fraction of a mile; and in some parts of its moraine-covered margin, on which forest grows, it has remained practically stationary for at least half a century. This extreme difference may possibly be in part due to a more constant maintenance of the ice supply in the Malaspina Glacier, though of this there is no proof; it certainly is *partly* due to the difference in rate of recession of glaciers terminating on the land and in the sea.

Modification of Local Climate as a Result of Advance and Retreat

In interpreting both the cause and the rate of advance or recession of glaciers it is evident that the mere fact of advance encourages advance, while recession encourages continuation of recession. When

a glacier advances, the area of ice surface is increased, and its level rises, while with retreat the glacier surface is lowered and the area of ice is decreased; and if the terminus is in the sea there is a variation in the amount of floating ice with advance or recession. These changes produce a very pronounced effect on local climate, influencing both snowfall and ablation. Though the extent of the influence is naturally variable, it is roughly proportionate to the amount of the advance or retreat and to the area and height to which the variation extends. Other things being equal, the influence of an advance in encouraging advance is greater and more prolonged when the ice ends on the land than when its terminus is in the sea; for on the land the ice spreads farther and remains in position longer. Thus the climatic influence of the last advance of Malaspina Glacier is still dominant, while that of the neighboring Hubbard Glacier has been very greatly reduced by its notable recession.

In illustration of these principles it may be stated that photographs of Hidden Glacier, which in the interval between 1905 and 1909 had advanced two miles and had become greatly thickened, show a very notable difference in the amount of snow on and above the ice. This is undoubtedly due to the double cause of greater snowfall and decreased melting, brought about by a modification of the local climate as a result of the advance. At Muir Glacier, which in the interval between 1892 and 1911 has suffered such excessive recession and lowering of its surface, the climatic difference is also distinctly noticeable in photographs, but with results of exactly the opposite kind. Here there is a smaller area of ice, the surface of that which remains is much lower than formerly, a larger proportion of the surface is covered with moraine or discolored by débris, and the snow-covered area on the mountain slopes is greatly diminished. Without doubt the depth of annual snowfall is markedly decreased, while the amount of ablation is notably increased in 1911, as compared with 1892. Thus when a deficiency of snowfall, or other cause gives rise to a recession, the rate of ablation may come to be considerably in excess of the amount by which the ice supply is deficient, and the rate of retreat therefore may become much more rapid than would be expected from the mere difference in ice supply.

Recession Following Advance

The problem of advance and recession is still further complicated by the apparent manner in which glacier advances take place. As shown by Finsterwalder and others,[16] the Vernagt Glacier of the Tyrol responds to climatic variations by the passage through the glacier of a wave which causes the terminus to move forward, the forward movement being concentrated in a brief period of time. Other glaciers, in the Himalayas, in Patagonia and in Spitz-

[16] Finsterwalder, S., "Der Vernagtferner," *Wissenschaftliche Erganzungshefte zur Zeitschrift des D. u. O. Alpenvereins*, 1. Band, 1. Heft, Graz, 1897; Anhang, Blumcke, A., und Hess, H., "Die Nachmessungen am Vernagtferner"; Blumcke, A., und Hess, H., "Beobachtungen an den Gletschern des Rofentales," *Mitt. des D. u. O. A.-V.*, Jahrgang 1900, Nr. 4; "Einiges über den Vernagtferner," *ibid.*, Jahrgang 1902, No. 18; "Tiefbohrungen auf dem Hintereisferner," 1902, *ibid.*, Jahrgang 1902, Nr. 21; "Tiefbohrungen am Hintereisferner im Sommer 1908," *Zeitschrift für Gletscherkunde*, Band III., 1909, pp. 232–236; "Tiefbohrungen am Hintereisgletscher," 1909, *ibid.*, Band IV., 1909, pp. 66–70; Hess, H., "Zur Mechanik der Gletschervorstosse," *Petermanns Geogr. Mitt.*, 1902, Heft V.; Hess, H., "Probleme der Gletscherkunde," *Zeitschrift für Gletscherkunde*, Band I., 1906, pp. 241–254.

bergen, whose ends have been rapidly and notably pushed forward are apparently illustrations of the same principle; and because of the peculiar nature of the cause for the wave, the Yakutat Bay glaciers furnish illustrations of an even more spasmodic movement, and a more rapid subsidence of the wave of advance. There are many instances of minor, or minute, advances of glacier fronts; and we also know of a number of cases of noteworthy advances in Alaska and elsewhere. The more notable advances seem to be illustrations of the same principle, that a wave of advance, concentrated on the terminus of the glacier, pushes it far forward; then follows a relative deficiency of supply and consequent retreat. In the recently advanced glaciers of the Yakutat Bay region the subsequent deficiency has been so great that stagnation has immediately followed advance.

We have not yet large enough body of fact to warrant the statement of a law, but such knowledge as we possess indicates that there is reason to expect relatively rapid recession following an advance, because a deficiency of supply follows as a necessary result of the utilization of a part of the ice supply in the progress of the wave of advance. In other words, the reservoir is temporarily depleted by the drain upon it during the advance.

Former Glaciation

The major part of this address has been devoted to the existing glaciers and their recent history, for this has been the field of my most extensive study. But little time remains for a consideration of the former glaciation, and what is said must of necessity be brief, and must deal with only the most general and fundamental points.

Extent of Former Glaciers

It is now a well-known fact that in recent geologic time there has been a very notable expansion of Alaskan glaciers both along the coast and in the interior. The fiords of southeastern Alaska were filled with ice to their seaward entrances, and the same was true as far west as the Alaska Peninsula. Thus there was a vastly greater ice-covered area on the seaward side of the coastal mountains than now exists there. In the interior there was also notable expansion on the inner side of the coastal mountains, on both sides of the Wrangell and Alaska ranges, and in the Endicott Mountains. Elsewhere in the mountains of the interior, even where now there are no living glaciers, there were valley tongues, and perhaps even expanded piedmont bulbs. All this glaciation was, however, purely of the mountain type, and far the greater part of Alaska was untouched by it.

Along the coast there were extensive piedmont glaciers, and there were vast piedmont ice sheets filling the fiords to a depth of several thousand feet, overflowing the low islands and peninsulas now separating them, and discharging icebergs into the ocean. Piedmont glaciers also developed along the inner face of the coastal mountains and on both sides of the Wrangell Mountains, and the Alaska Range.

By far the greatest area of ice in the interior was that which, in its maximum stage, nearly or quite filled the great basin that lies between the coastal mountains, the Wrangell Mountains and the Alaska Range, forming a great *intermont* glacier by the junction of a series of piedmont glaciers. The exact extent and the characteristics of this glacier are not yet determined; and it is not certain that it filled the entire Copper River Basin, though it

probably did, and even extended into the Susitna Valley.

Deposits of Former Glaciers

The deposits of this former glaciation are not usually extensive among the mountains, whence they have easily been removed by subsequent denudation; nor are they very notable in most places along the coast, for there the greater portion of the deposits doubtless lies beneath the sea. Only in a few places, as in the foreland that skirts the seaward base of the Fairweather Range, is there an extensive area of deposit above sea level; elsewhere the general scarcity of glacial deposit is usually striking.

In the interior, on the other hand, and notably in the Copper River Basin, there is a remarkable development of glacial and glacio-fluviatile deposit formed during the period of glaciation and during its stages of advance and of recession, of which the present must be considered a part. Here one finds the greater number of glacial features common to an area of continental glaciation—lake and glacial stream deposits, loess, till, eskers, kames, moraines, and marginal channels are found in perfect development over a wide area. One familiar with glacial deposits in Europe or America finds himself quite at home in the Copper River Basin.

The Period of Expansion

There has not been enough study of the glacial deposits to render it possible to state whether the history of the glaciation in Alaska presents the same complexity as that observed in Europe and eastern America; nor can it even be assumed that the Alaskan glaciation was contemporaneous with the glaciation of these lands. Yet, although very extensive glaciers still exist in Alaska, and although these are certainly the descendants of the former expanded glaciers, it is entirely possible that the time since the maximum expansion is as great as that in other northern lands, such as Norway and Scotland. I can see no noticeable difference either in the extent of post-glacial denudation, or in the weathering of glacial deposits in Alaska and the Alps, or Norway, or Scotland. The greatest expansion of Alaskan glaciers certainly occurred many centuries ago, and may well have been as long ago as the time when the glaciers of the Alps shrank back into the mountain valleys. The vast work performed by glacial erosion in the Alaskan fiords clearly proves that the period of expansion of glaciers was of long duration.

Difference in Extent of Recession

There is one very puzzling condition that renders the solution of the problem of the time of maximum expansion difficult to solve. In southeastern Alaska and in Prince William Sound the tidal glacier fronts now lie from 75 to 100 miles farther back than they were in the period of greatest expansion, and vast areas of land and water have been uncovered by the recession of the glaciers. So also there has been a very large area uncovered by glacier recession in interior Alaska. But in the coastal area between Cross Sound and Prince William Sound, the glaciers of to-day appear to be only slightly less extensive than they were at the maximum. According to G. C. Martin,[17] the present surface of Martin River Glacier is only 600 or 700 feet lower than during the maximum glaciation, while Bering Glacier is only about 200 feet lower; and the horizontal extension of the glaciers at the period of maximum expansion was only very slightly beyond the

[17] Martin, G. C., "Geology and Mineral Resources of the Controller Bay Region, Alaska," Bull. No. 375, U. S. Geol. Survey, 1908, pp. 50–52.

present borders. Malaspina Glacier has shrunk more than the Bering, but even this is far nearer the maximum than the glaciers of Prince William Sound toward the west, or those of the Inside Passage to the southeast, or those of the interior to the north. In the same region with Malaspina Glacier, the expansion of the Nunatak-Hidden Glacier, of a century or more ago, extended to within 10 or 15 miles of the earlier maximum.

From these facts it is evident that locally, near the center of the coastal area of Alaskan glaciation, the present day glaciers are only a little short of their former maximum. This may be due to recent extensive uplift of the mountains in which these glaciers have their source, or to other local causes; or the entire history of Alaskan glaciation may be related to changes in elevation, and wholly unrelated to those causes that gave rise to the development of continental glaciation in Europe and eastern North America. We are not now in possession of a sufficient body of fact to warrant further discussion of this problem.

CONCLUSION

This brief analysis makes it clear that up to the present time only a beginning has been made in the research in the field of Alaskan glaciers and glaciation. Enough has been done, however, to show the existence of interesting and important problems, to permit a few of them to be set forth in concrete form, and to discover facts that have a bearing upon some of them. But there is so much yet to be learned, so many more facts are needed, there is so wide a field that is wholly unknown, and the period of observation is so limited that any one who undertakes to consider the general problems of this broad and complicated field can not but feel appalled at the limitations surrounding his attempt. At best, with all the help that he can obtain from the work of others, he can only hope to make a step toward the understanding of the conditions and problems of this great field. I do not delude myself with the belief that in this address I have done more than this.

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PROFESSOR GEORGE DAVIDSON

In San Francisco on December 1, 1911, Professor George Davidson quietly ended a long life of active and valuable service to his country. Men of science the world over are expressing their sorrow at his passing, but everywhere there swells also the strong note of pride and satisfaction in the magnificent example which he has given of what may be accomplished by the devotion of a clean, strong life to a chosen field of work. Beginning his independent scientific observations in 1843 as magnetic observer for Girard College, he devoted sixty-eight years of virile manhood to geodesy, geography and astronomy. For fifty years of this long period he was uninterruptedly in the service of the United States Coast and Geodetic Survey. Three years after his retirement in 1895 from the survey he was elected to the professorship of geography in the University of California, with which institution he was connected to the time of his death. This change in his nominal employment made, however, no serious break in the continuity of his life of study and research. The exceptional character of his mental and physical virility is strikingly shown by his election to the faculty of the University of California at the age of 73—eight years beyond the limit usually fixed for the retirement of college professors.

Few men can read the brief sketch which follows without some feeling of surprise that the life of a contemporary should reach so far back into the history of another generation. Born in Nottingham, England, on May 9, 1825, in early boyhood he was brought to the United States by his parents, who settled in

Pennsylvania in 1832. He was educated in the Central High School of Philadelphia, an institution which by the school organization of that time was entitled to confer college degrees and which had an able corps of instructors. Among the faculty was Professor A. Dalles Bache. Professor Bache's high regard for the young student led to his appointment, in 1843, as magnetic observer at Girard College. Meanwhile Professor Bache was made superintendent of the United States Coast Survey and in 1845 young Davidson, then only 20 years of age, was appointed as clerk and computer to serve in the office of the superintendent. This appointment determined his life work, for he remained in the service just one half century. In 1850 at his request he was assigned to duty on the Pacific coast, where for the next ten years he surveyed harbors, selected sites for lighthouses and determined geographical positions along the coast from San Diego to Puget Sound. This pioneer work was of the greatest importance to navigators, his observations during this period being the foundation for his "Coast Pilot or Directory of the Pacific Coast," the first edition of which appeared in 1857.

At the outbreak of the civil war he was assigned to the Atlantic coast, where he was first employed as engineer on the defenses of the Delaware River. In 1862 he was in charge of the Coast Survey steamer *Vixen*, detailed for special naval service along the Florida coast. The next year, when Lee invaded Pennsylvania, he was made assistant engineer of Philadelphia.

The frequent connection of Professor Davidson with important events in the history of the United States is well illustrated by his assignments for the year 1867. In January he was detailed on duty as engineer of a party sent to the Isthmus of Panama to search for the best location for a ship canal. A few months later he was in Alaska making a preliminary geographical survey of that territory, the purchase of which was then being negotiated by the United States. His report on Alaska met the warm approval of Secretary of State Seward, and greatly influenced the consummation of the purchase. One rare accomplishment of Professor Davidson was his ability to do reconnaisance quickly and effectively—an especially valuable quality for a man doing scientific work in a new country.

In 1868 he was promoted to charge of the United States Coast Survey on the Pacific coast, a position which he retained until June, 1895. This period was in many ways the richest and most productive of his life. He not only directed the work of the various field parties and personally made some notable geodetic and astronomical surveys, but he also served on government commissions in various parts of the world.

In 1872 and again in 1884 he was appointed by the President upon the Assay Commission to test the weight and fineness of the coins of the Philadelphia Mint, and in both instances made all the weighings and introduced new methods. Twice he was appointed by the Secretary of the Treasury to examine the assay, coin and bullion weights and the ballances and beams of the United States Mint at San Francisco.

In 1873 he was appointed by President Grant one of the three commissioners of irrigation of California, and in the following year was sent to China, India, Egypt and Europe to examine and report upon irrigation and reclamation works. In 1888 President Cleveland appointed him a member of the Mississippi River Commission. In 1889 he was appointed by President Harrison a delegate to the International Geodetic Convention at Paris, and was commissioned to bring to Washington the international prototypes of the standard meter and kilogram. While abroad on this mission he visited the observatories of Paris, Berlin and Greenwich, and was received with high honors.

Many scientific societies have elected him to membership: Bureau des Longitudes de France; honorary member Berlin Geographische Gesellschaft; Royal Geographical Society; Scottish Royal Geographical Society; Swedish Society of Anthropology and Geography; Paris Academy, Institut de France; the Philadelphia Academy of Science in 1853;

of the National Academy of Science in 1874, and many others. He was president of the Geographical Society of the Pacific since its organization in 1881. He received the degree of Ph.D. from Santa Clara College in 1876; Sc.D. from the University of Pennsylvania in 1889, and LL.D. from the University of California in 1910. Norway conferred upon him the Cross of the Royal Order of St. Olaf in 1907, and the American Geographical Society awarded him the Charles P. Daly medal in 1908.

In California he was frequently called upon to give advice in the great engineering problems of San Francisco and of the state. He served as regent of the University of California from 1877 to 1884, and was a member of many state commissions. It was largely through his suggestion and influence that James Lick finally decided to build and endow the great Lick Observatory.

Professor Davidson is also favorably known for his accurate astronomical work. He was in charge of the solar eclipse expedition to Alaska in 1869 and took his 6½-inch equatorial to the top of Santa Lucia (over 6,000 feet) to observe the total eclipse of 1880. He had charge of the American Transit of Venus Expedition to Japan in 1874 and of the party to New Mexico for the transit of 1882. The Davidson Observatory in Lafayette Park, San Francisco, where he made many valuable observations, was established and maintained by him for twenty years. His remarkably fine drawing of Saturn is a monument to his acute eyesight and to his delicate skill in delineation.

The name of Davidson is inseparably connected with the foundations of accurate map work in the state of California. His long study of the coast line is embodied in the many survey charts and in the final edition of his "Coast Pilot," which was published in 1889. The north-flowing current now known as the Davidson inshore eddy, was discovered by him and studied particularly in regard to its effect upon harbor improvements.

The only base lines in California, the lines upon which all the distances involved in the extensive triangulation of the state depend, were located and accurately determined by Professor Davidson, the Yolo base line being twice measured by him in 1881 and the Los Angeles base line three times in 1888–89. A recent report of the Coast and Geodetic Survey puts the probable error in this work as about the one-ten-thousandth part of one per cent. The location of the northeastern boundary line of California, the 120th meridian, was finally determined by him in 1873, and the diagonal boundary of 405 miles from Lake Tahoe to the Colorado River was located and marked under his supervsion in 1893. This line is interesting because at each end it terminates in a body of water.

This fragmentary account affords but an imperfect idea of the breadth and scope of the work of Professor Davidson. The fact that in all the many problems of his main work his scientific accuracy stands practically unchallenged is due to his wonderful capacity for untiring effort, to his acute eyesight as an observer, and to his fixed habit of patiently and conscientiously verifying every observation.

In the seventies, when reoccupation of some of his old stations by later parties threw some doubt on his observations fixing the exact position of Mt. Tamalpais, he boldly asserted that his work was right, that the mountain might have moved, but that he had correctly determined its location at the time. After the earthquake of 1906 there was made a careful and extensive survey of central California, which, compared with the surveys before and after the earthquake of 1868, confirmed the accuracy of Professor Davidson's original observations and also his explanation of the apparent discrepancies.

Simple and unassuming in appearance, he bore the mark of one accustomed to command, and possessed a strong and dominating personality. The men who served under him learned at once to obey unquestioningly his slightest order, yet his warm-hearted and generous nature caused them to be strongly attached to him. It has been said that his life work extended through sixty-eight years of active manhood, and rightly so, although one in-

firmity partially disabled him in later years. He was made professor emeritus in 1905 and freed from any obligation to do university work, yet he voluntarily continued his classes for two years in spite of failing eyesight. The necessity of submitting to an operation for cataract finally compelled him to give up lecturing. Although the operation was but partially successful, several papers were prepared by him in these later years. Professor Davidson's indomitable will kept him at work when he was able to read only through a narrow slit in blackened cardboard under favorable light and with the help of the strongest glasses.

Under such circumstances he wrote and published in 1908 his paper on "Francis Drake on the Northwest Coast of America" and, in 1910, the paper on "The Origin and Meaning of the Name California." Both these papers necessitated the careful reading of old maps and manuscripts and yet every point was verified and compared in his manuscript and also in final proof with his original source of information.

To the last he stood as erect as a young soldier, and his voice rang with the courage that he never lost. To those who knew him personally his memory will be treasured because of his warm heart and manly character. The record of his life is an inspiration toward untiring conscientious scientific work.

Ruliff S. Holway

MUSEUM EXTENSION WORK IN CHICAGO

Three years ago the Chicago Academy of Sciences undertook an educational and museum extension policy which was new in that city. The work has been done in cooperation with the public and private schools of the city. Nearly one hundred museum loan collections have been prepared for distribution among the schools. During the year 1911, 279 loans were made to 44 different schools. Each collection thus loaned was used with at least fifty children and, in many cases, with several hundred children before it was returned to the academy. It is estimated that in this way the loan collections have been used during the past year with upwards of 20,000 children.

Instructional courses were offered at the academy free of charge to the children who wished to come. These classes were so crowded that a delegate plan was devised which is probably unique in museum work. Each school room of a given grade may select a representative and that representative comes to the academy as a "little reporter." With note-book and pencil in hand, and with ready questions, these "reporters" make every effort to be well prepared to transmit to their classmates the lessons of which they have had the advantage. In this way the instructional work of the academy has been reaching thousands of children in the public schools each week. Fifty-six schools were represented by 553 delegates in the instructional courses at the academy. Through this method of representatives from the different classes, the work of the academy during the past year has been reported to many children.

Instructional courses to teachers were given. Some of these courses were in the laboratory and others in the field. The teachers were organized into groups to carry on special studies in the plant and animal life of the Chicago region. The study of birds and wild flowers were perhaps the most popular courses thus undertaken.

The transition of the academy from a natural history museum, organized chiefly for the benefit of its members, to an active educational institution conducted chiefly for the benefit of the community, has been carried on under the leadership of the president, Professor T. C. Chamberlin, head of the department of geology at the University of Chicago. The educational work was entrusted, three years ago, to Dr. Wallace W. Atwood, who has had immediate charge of the development of this phase of museum extension work and has organized the various courses of instruction and the methods of taking the museum to the people and especially to the children in the schools. Mr. La Verne W. Noyes, president of the board of trustees, has taken an active interest in the development of this

phase of the instructional work of the institution and has made many suggestions which have proved successful. The latest plan in museum extension work is the preparation of special museum loan exhibits. One of these special exhibits has just been prepared and is ready to be placed in the public schools, park houses, social settlements and branch libraries. The exhibit is entitled "Birds Wintering in the Chicago Region." The foreground is a miniature reproduction of the shore of Lake Michigan. Eleven birds are placed in the foreground and, by means of an oil painting, the scene is carried far into the distance. This is a type of habitat group which will be distributed and loaned free of charge. In this way a modern piece of museum work will be taken to many who may not have an opportunity to visit the main building. The ideas of museum extension is being taken up by various other organizations in the city. The Woman's Club has installed civic and health exhibits in the public schools. The social settlements, the School of Civics and Philanthropy, Municipal Art League, Council for Museum and Library Extension, are all at work on plans for special exhibits at educational centers. This is a period of unusual activity in this field and the recent gift of Mr. N. W. Harris of $250,000 to the Field Museum will make possible still larger development of this movement in Chicago. The influence of this activity within the city is being felt throughout the state and many calls are received from rural districts for museum loan collections. The Illinois Audubon Society has made some provision for meeting this demand throughout the state. It has in constant use four traveling libraries, four bird-picture collections and two lantern-slide collections with accompanying lectures. These are distributed free of charge. The Chicago Child Welfare Exhibit has aroused wide-spread interest in the preparation of special exhibits for educational purposes.

THE AMERICAN MUSEUM OF NATURAL HISTORY

The forty-third annual meeting of the trustees of the American Museum of Natural History was held Monday evening, February 5, 1912, at the Union Club, where the trustees were the guests of Mr. Thomas DeWitt Cuyler, of Philadelphia.

The following were elected officers for the ensuing year:

President—Henry Fairfield Osborn.
First Vice-president—Cleveland H. Dodge.
Second Vice-president—J. P. Morgan, Jr.
Treasurer—Charles Lanier.
Secretary—Archer M. Huntington.

The president presented his annual report and announced the gift to the museum of the Catlin collection of Indian paintings, which was presented by Mr. Ogden Mills, and the Bailey collection of meteorites, which was the gift of Mr. J. P. Morgan, Jr.

According to the president's report, the total attendance for the year was 724,141, which is 100,000 greater than the attendance of last year; the number of pupils studying the circulating collection was 1,253,435, an increase of 300,000 over 1910; the membership has been increased by the enrolment of 349 new members.

Plans are being formulated for the celebration of the fiftieth anniversary of the founding of the museum, on April 6, 1919.

A comparison of the expenditures for the year shows that while the city's contribution was $189,757, the trustees and the friends of the museum contributed $216,404.

The building plans for the future include the construction of an east entrance hall on Central Park West and an entrance hall opposite 79th Street on Columbus Avenue. The future exhibition halls that are under consideration are the

Geographic Hall, East Wing, First Floor,
African Hall, East Wing, Second Floor,
Oceanographic Hall, Southeast Wing, First Floor,
Whale Court, Southeast Court, First Floor,
Ichthyology Hall, Southeast Wing, Second Floor.

The president emphasizes the necessity of increasing the present endowment fund.

Election to Membership: Mr. Ogden Mills was elected an associate benefactor in recognition of his gift of the Catlin collection of Indian paintings. Mrs. Isaac M. Dyckman was elected a patron in recognition of her con-

tribution for the preparation and publication of a bibliography on fishes. The Duke of Bedford was elected a fellow for his generosity in presenting to the museum two fine examples of the Prjevalsky horse, a species which has hitherto been unrepresented in the collections. Mr. Anthony R. Kuser was elected a fellow in recognition of his offer to present to the museum a collection of pheasants of the world. Lieutenant George T. Emmons was made an honorary fellow in recognition of his services in furnishing information in regard to the Indians of the Northwest Coast and in promoting field work in this region. Mr. George Bird Grinnell was elected an honorary fellow in recognition of his services in the development of the museum's department of anthropology. Sir Ernest Shackleton was elected a life member in recognition of his splendid achievements in the field of exploration, as well as for his generosity in presenting to the museum a collection of minerals from the south polar region. Dr. Leonard C. Sanford was made a life member in recognition of his generosity in placing his superb collection of birds of the world at the disposal of the curators of the museum for study and reference.

CATLIN PAINTINGS

George Catlin was the first great Indian painter and writer. He was born in Wilkesbarre, Pennsylvania, in 1796, was educated as a lawyer, but in 1823 gave up the profession for art, opening a studio in Philadelphia. A few years after he painted the famous portrait of Mrs. Madison and that of Governor De Witt Clinton, now hanging in the City Hall of New York. He early became a miniature painter, a collection of his works being in the hands of a private collector in Minnesota. Once a delegation of Indians passing through Philadelphia on the way to Washington so impressed Catlin that he planned to travel and paint the various wild tribes. Accordingly he set out and spent eight years, during which time he visited forty-eight different tribes, making portraits and sketches of scenes from daily life. Some years afterward he issued a large illustrated work on the North American Indians which is still one of our most important publications. Mr. Catlin died in New York City in 1872, leaving in the hands of his daughter, Miss Elizabeth W. Catlin, a large collection of paintings and sketches, which has just been acquired by the museum.

This collection, comprising some 350 oil paintings, represents chiefly the tribes between the Mississippi and the Rocky Mountains as observed during the years 1832 to 1840. Many of them are the originals for the plates in the author's well-known books. Their historic value is very great, as they are the earliest authentic sketches representing the costume, ceremonies, habitations, etc., of the wild tribes. At the time Catlin visited these tribes they were practically uninfluenced by civilization. A well-known artist says: "This collection is by far the most interesting and complete in existence and for the Indian artist is invaluable, the subjects represented covering the entire life, costumes, ceremonies, etc., at a time when Indian life was real, that is, before the transition period in Indian history. I have known Indians for forty years and have seen many who were very little influenced by contact with the white man and I can vouch for the truthfulness of these pictures. They are, outside of Bodmer's and Captain Eastman's pictures, the only record we have of the Plains Indians and are valuable as a pictorial record. I want to speak of another view which the scientist does not appreciate. These Catlin pictures are the most decorative Indian pictures that have ever been painted. There is not a picture in the collection that I would not be proud to hang on my wall. They have a grand beauty of line composition, a great harmony of tone that makes them very valuable as works of art. They have the scenic charm of a Japanese print."

Thus, Catlin may be considered the original Indian artist, the predecessor of Curtis, Schoolcraft, McKenna and Hall and a host of lesser lights. For the museum, the collection will be especially valuable, since it gives us not only highly decorative canvasses, but illustrative series which may be installed

among the ethnological collections where the various scenes will show to the visitor Indian life as it once was.

Perhaps the most unique portion of the collection is the South American sketches. Alexander von Humboldt, whom Catlin met in Europe, was so impressed with the work that he urged Catlin to spend some time traveling in South America. Accordingly, in 1852, Mr. Catlin set sail for Venezuela, from whose coast he passed into the interior and over into the valley of the Amazon. For six years he explored South America, visiting all the tribes on the Pacific Slope, wandering through Yucatan, and portions of Old Mexico and later sailing for Buenos Ayres, from whence he ascended the Parana River to the north and again traversed the entire coast line of Patagonia through the Straits of Magellan. As a result of this work we have ninety canvasses representing characteristic scenes among the natives of tropical and other portions of South America.

BAILEY METEORITES

Through the generosity of Mr. J. P. Morgan, Jr., the museum has acquired the collections of meteorites and minerals that were left by the late Mr. S. C. H. Bailey. Mr. Bailey was an indefatigable collector and exchanger in both branches of science, and his series of meteorites was known as one of the largest in private hands in the number of falls and finds represented. About three hundred meteorites were received by the museum, many of which are new to its already large collection. The most important fall represented is that known as Tomhannock, on account of its having been found on Tomhannock Creek, near Troy, Rensselaer County, New York. Only six meteorites, four iron and two stone, have been discovered within the limits of the state, five of which have been cut up and distributed throughout the collections of the world and most of the larger pieces are in European museums. The main mass of Tomhannock, however, remained with Mr. Bailey, and the museum is fortunate in coming into possession of it. It is an aerolite, or stone meteorite, which was first discovered in 1863, but was not described until 1887, when Mr. Bailey gave it its present name. The entire original mass weighed only about three and one half pounds, was well rounded and covered with the fusion crust so characteristic of meteorites. Only about one tenth of the original mass was cut off and divided among museums. Hence the part that has now come to the American Museum is nearly nine tenths of the original.

SCIENTIFIC NOTES AND NEWS

Lord Lister died at his home in London on February 11 at the age of eighty-four years.

At the annual meeting of the Royal Meteorological Society on January 17 the president, Dr. H. N. Dickson, presented to Professor Cleveland Abbe, of the U. S. Weather Bureau, Washington, the Symons gold medal for 1912, which had been awarded to him in consideration of his distinguished work in connection with instrumental, statistical and dynamical meteorology and forecasting.

M. Maurice Maeterlinck, who last year received the Nobel prize for literature, proposes to raise the sum to $40,000, and to employ it to establish a biennial prize of $3,200 to be awarded to the author of the most remarkable work—whether on literature, art or science—published in the French language.

Sir William Ramsay, for twenty-five years professor of chemistry at London University, has submitted his resignation, and the senate has resolved: "That the senate accept Sir William Ramsay's resignation with sincere regret, and desire to express to him their high appreciation of the services which he has rendered to the university both by his inspiring work as a teacher and by the great series of researches carried out by him at University College during his tenure of the chair of chemistry."

Professor Rubner, director of the Berlin Hygienic Institute, has received the large gold Rinecker medal of the University of Würzburg.

We learn from *Nature* that the Rhodesia Scientific Association's gold medal, recently

offered for an original paper advancing the knowledge of the transmission of any insect or arachnid-borne disease affecting Rhodesia, has been awarded to Dr. Edward Hindle, Beit memorial research fellow, for his paper on "The Transmission of *Spirochæta duttoni.*"

AT the January meeting of the Chicago Academy of Sciences the following officers were elected: *President,* Dr. T. C. Chamberlin; *First Vice-president,* Professor C. B. Atwell; *Second Vice-president,* Dr. Henry C. Cowles; *Secretary,* Dr. Wallace W. Atwood.

DR. ANGEL GALLARDS, biologist, has been appointed director of the Museo Nacional, Buenos Aires, in the place of the late Professor Florentino Ameghino.

DR. FREDERIC A. LUCAS, director, has been appointed to represent the American Museum of Natural History at the Centenary of the Academy of Natural Sciences of Philadelphia, March 19–21, 1912. Dr. W. D. Matthew, curator of the department of vertebrate paleontology, has been appointed to represent the museum at the celebration of the one hundred and twenty-fifth anniversary of the University of Pittsburgh, February 27–29, 1912.

MR. FREDERIC G. HALLETT, secretary to the examining board of the Royal Colleges of Physicians and Surgeons, has left London for the United States, having been invited by the council on medical education of the American Medical Association to attend the conference on medical education to be held in Chicago on February 26, and to address the meeting on the subject of the methods of conducting examinations for licenses to practise medicine adopted by the conjoint examining board in England.

THE University of Michigan has granted a leave of absence to Professor William H. Hobbs for the academic year 1912–13. In his absence from the university, the charge of the department of geology will devolve upon Professor E. C. Case. Professor Hobbs's classes in geology will be conducted by Professor Frank Carney, head of the department of geology at Denison University. Professor Hobbs will devote the year to study and travel abroad.

THE yacht *Anton Dohrn,* of the department of marine biology of the Carnegie Institution of Washington, will make a cruise to Andros Island, Bahamas, in April and May, the chief objects being to provide an opportunity for Dr. T. Wayland Vaughan to continue his studies upon coral reefs, and to permit G. Harold Drew, Esq., B.A., of Cambridge University, to pursue his researches upon the denitrifying bacteria of tropical seas. Dr. Paul Bartsch will also study the ecology of the molluscan fauna, and trawls with self-closing nets will be made in the deep tongue of the ocean.

THE third Hamilton fund lecture of the Smithsonian Institution was delivered by Dr. Simon Flexner, director of the Rockefeller Institute for Medical Research, in the auditorium of the U. S. National Museum on February 8. The title of the lecture was "Infection and Recovery from Infection."

DR. R. M. PEARCE, professor of research medicine in the University of Pennsylvania, gave a course of five lectures on the Hitchcock foundation, at the University of California from January 22 to 26. The subjects of the lectures were as follows: "Antiquity to 1800—The Efforts of Isolated Investigators," "The Development of Laboratories for the Medical Sciences," "Pasteur and the Rise of Bacteriology," "Present Day Methods and Problems," "Medical Research in American Universities, Present Facilities, Needs and Opportunities."

THE Ichabod Spencer foundation lectures are being given at Union College by Professor Hugo Münsterberg, of Harvard University. His subject is "Applied Psychology."

AT a recent meeting of the Biological Science Club, of Oberlin College, Professor L. James, associate professor of animal ecology, gave an address covering some phases of his special research work upon the migration of birds, carried on during the summer at Pt. Pelee, Lake Erie.

Mr. Calvin W. Rice, secretary of the American Society of Mechanical Engineers, was the guest of the student branch of the society in the College of Engineering of the University of Illinois on January 23 and 24. In an address before the members of the society, Mr. Rice emphasized the importance of every engineer being interested in the national engineering societies. Mr. Rice was entertained by the local members of the society at a dinner at the University Club in the evening of the 23d.

Professor E. H. S. Bailey, director of the chemical laboratories in the University of Kansas, has been granted a leave of absence for the remainder of the school year 1911–12, and will leave immediately for Europe, where he will make a study of foods, investigating market conditions and food supplies.

UNIVERSITY AND EDUCATIONAL NEWS

Gifts, aggregating $81,291, have been announced by the trustees of Columbia University including $30,000 from Dr. William H. Nichols for instruction and research laboratories in chemistry; $25,000 from Mrs. Russell Sage, for the E. G. Janeway Library endowment fund at the medical school; $15,000 from W. Bayard Cutting, to establish the William Bayard Cutting, Jr., fellowship in international law, and $10,000 from Augustus Schermerhorn, to be expended for the current needs of the university. Dr. Theodore C. Janeway has given to the trustees the medical library left to him by his father, Dr. Edward G. Janeway.

The completion of the half million endowment fund for Oberlin College has made possible the following additions to the college resources: the men's building, $150,000; a new administration building, $50,000; the completion of the men's gymnasium, $30,000; a part payment on Keep Cottage, the new women's dormitory, of $10,000; for higher salaries, $200,000, and other endowments, $60,000; thus making a total of $240,000 for buildings and $260,000 for salaries and other endowments. Among the donors were the following: anonymous, $200,000; a friend, $50,000; Dr. L. C. Warner, of New York City, $40,000; Mr. and Mrs. G. N. Clark, of Evanston, Ill., $10,000; Charles M. Hall, of Niagara Falls, N. Y., $10,000; an eastern friend, $12,000; Mrs. D. Willis James, of New York City, $10,000.

Transylvania University has announced that the effort to raise a fund of $250,000 has been successfully completed. The largest gifts aside from $50,000 offered by the General Education Board in May, 1910, were as follows: $30,000 from R. A. Long, of Kansas City; three gifts of $15,000 each from W. P. Bowers, of Muncie, Ind., Geo. H. Waters, of Pomona, Calif., and J. J. Atkins, of Elkton, Ky.; $9,000 from M. F. Pearce, of Covington, Ky., and four gifts of $5,000 each. The remainder of the fund was provided in many smaller amounts.

Contracts have been let for the erection of a new laboratory of mining engineering and a new ceramics building at the University of Illinois. Two other buildings, the commercial and the woman's building, are being constructed and plans are nearly completed for a new armory, stock pavilion and transportation building.

At a recent meeting of the court of the Goldsmiths' Company the following grants were made to the senate of the University of London: For the building fund of King's College for Women, £10,000; for the endowment fund of Bedford College for Women, £5,000; for the building and equipment fund of the chemical department of University College, Gower Street, £1,000. The company has also made a grant of £1,000 to the National Physical Laboratory at Teddington for the equipment of the metallurgical department at that institution.

Dr. Robert Davies Roberts, secretary of the Congress of the Universities of the Empire and chairman of the executive committee of the University of Wales, who died on November 14, aged 60, left an ultimate residue legacy to the University College of Wales at Aberystwith, to form the nucleus of a fund "to enable professors after a certain number

of years of service, say not less than ten, to be released from the professorial duties for a period of about a year, and, at any rate, not less than six months on full salary, a substitute being paid out of the income of the fund; the purpose of this release from college duties being to enable the professor to refresh his mind by travel or research or visits to other universities, and so gain fresh stimulus and equipment for his work."

The University of Pittsburgh will celebrate its one hundred and twenty-fifth anniversary on February 27, 28 and 29, 1912. The first charter was granted to the Pittsburgh Academy on February 27, 1787. In 1819 it became the Western University of Pennsylvania, the name being again changed in 1908 to the University of Pittsburgh. Educational conferences will be held on Tuesday, February 27. On Wednesday, February 28, an historical address on "The Progress of Higher Education since 1787" will be given by Chancellor Kirkland, of Vanderbilt University. This address will be followed by the conferring of honorary degrees. In the afternoon an historical address on the University of Pittsburgh will be given by former Chancellor Holland, followed by addresses by representatives of educational institutions. On Thursday, February 29, there will be conferences of the college presidents of Pennsylvania and secondary schools of western Pennsylvania. The visiting guests will be entertained at luncheon on each day of the anniversary celebration and at the alumni anniversary banquet on Wednesday evening.

By vote of the faculty of Oberlin College, the budget for the current year contains a special appropriation to be used in defraying the expenses of administrative officers, professors and associate professors who wish to attend meetings of scientific societies and other gatherings of a professional nature. The faculty is divided into ten groups, and each has a proportionate share in the general fund.

The inauguration of President Hibben of Princeton University will take place on the morning of Saturday, May 11.

Father Alexander J. Burrowes, S.J., a native St. Louisian and now the head of Loyola University, has been elected president of St. Louis University, succeeding Father G. P. Frieden, S.J., who died suddenly two months ago.

DISCUSSION AND CORRESPONDENCE

PROFESSOR JENNINGS AS A BIOLOGICAL PHILOSOPHER

Not for many a day, according to my notion, has anything more significant taken place in the biological realm than Professor Jennings's presidential address on "Heredity and Personality" before the American Society of Naturalists at its recent meeting (Science, December 29, 1911).

How splendid an era of biological achievement will have been ushered in when men of Jennings's rank shall come forth from their laboratories upon occasion and discuss, without feeling the need of apology for doing so, the infinitely large as well as the infinitely small problems of our science! This address augurs for Jennings as commanding a place in the larger biology as he now holds in the smaller.

Concerning the particular road, namely, that of genetics, by which Professor Jennings has come so near the edge of the woods of biological minutism I shall say little at this time. Rather it is about his rôle as philosopher, or better as metaphysician, that I wish to speak. In the first place I want to express my gratification at the clear evidence furnished by this address particularly, that he possesses both the aptitude and the courage to be the successor of Brooks, not merely as a professor of zoology but as an upholder of the rights and dignity of the philosophical side of biology. In the second place I am going to claim the privilege usually accorded to seniority of years and counsel Jennings against the supposed necessity of apologizing for the violation of good biological manners when he yields to his inclination to talk to fellow biologists on large subjects.

Now as to the problems raised. I do not, as already said, propose to go far into the sub-

ject matter of these at present. My chief wish is to point out what, as I see them, they are historically; and to state in language not primarily biological, but rather psychological and logical, what I conceive to be the central one among them.

When the man who is a biologist comes, as he sooner or later must come, upon the problems of the *"I,"* the *"not-I,"* the *"self," "personality," "potentiality,"* and the rest, he is doomed to almost complete failure in his attempt to deal with them unless he supplements, whole-heartedly and with much pains, the methods to which he is accustomed in his usual field and laboratory researches by at least some of the methods of the introspective psychologist, the logician and the metaphysician. The main reason why this is so is that our senses and our minds are just as truly instruments of research—parts of our laboratory equipment—as are our microscopes, our mother tongue, and our mathematical formulæ. Consequently to neglect to inform ourselves somewhat as to the principles of construction and mode of working of these personal instruments is to be mere rule-of-thumb workmen, just as similar neglect of the principles underlying our microscopes and language and mathematical formulæ would make us rule-of-thumb users of these means of research. The biologist who has given no attention to the way sense perception, and imagination, and rational process enter into a laboratory investigation has no more claim to be considered a genuinely scientific biologist than has a druggist's clerk to be considered a genuinely scientific chemist.

When one passes beyond the state of the raw empiricist in the use of his personal tools of research he soon comes upon the retinue of questions raised by Professor Jennings, and finds himself face to face with such live historical questions as that of the meaning of *radical empiricism;* as that of what the real kernel of *psycho-physics* is; as that of what is actually at the bottom of the conception of *"things-in-themselves,"* of Berkeley's *esse est percipi,* of Descartes's famous *cogito* dictum, of the Schoolmen's endless troubles about *matter* and *form, substance* and *accident,* of the early Church Fathers' warrings over the *Logos* and the *Trinity,* of Plato's *Ideas,* of the Chinese Buddhist's *Bodhisattva,* of the Vedic poet's *deva* and *vasu,* of the Melanesian's *Mana* and of innumerable other words and phrases found wherever the deeper instincts and desires and strivings of human beings have found expression in terms that mean any thing at all to other human beings. Vital knowledge of these matters does not imply vast learning. In these days when books on all subjects under heaven are almost as abundant and accessible as the leaves on the trees nothing is requisite to make every educated person informed in these regions beyond the recognition of how vital such knowledge is, and industry, economy and discrimination in the use of his time.

So much for the historical setting of the problems. Now a little as to what, substantively, the central one among them is. It is the two-fold problem as to just how all knowledge of nature, be it ordinary or scientific, is built up, and whether there is any knowledge whatever that does not contain, on the one hand, essential elements of sense perception, and, on the other hand, essential elements that can not be derived from sense perception, but have their seat at deeper depths than sense.

All I am going to say toward an answer to this question is this: If Professor Jennings will tackle again his exceedingly interesting questions of how long a "pure line" may be, and how many knots there are in the web of organic existence, starting this time from the standpoint of the "standardized reality" suggested by me a few years ago,[1] and will work at it as devotedly as he does at problems of animal behavior and genetics, he will find no more possibility of getting into the limbo he seems to be in over reincarnation than of getting ensnarled in the problem of whether there is anywhere in the universe a place in which *cubes are spherical in shape.* To be

[1] "Life from a Biologist's Standpoint," *Popular Science Monthly,* August, 1909, p. 180.

more specific, he will find that in his phrase "If . . . I am a redevelopment of the characteristics of some former individual from a piece of his body," the words "I" and the group of words "characteristic of some former individual" exactly cancel each other and leave an intellectual blank, just as do the words "cubical" and "spherical" when the attempt is made to apply them to one and the same body. That is to say, despite the splendid combination of breadth of outlook and ability as a laboratory methodologist and technicist which distinguishes Jennings as a biologist, his address at this point is subject to the same miscarriage of reason that has characterized nearly all modern speculative thinking on the Mendelian type of inheritance. The miscarriage to which I refer arises from neglecting the technical detail of noticing that since there always is a strictly psychological or subjective element in the idea expressed by the term "characteristic," it comes about that the very construction of the sense-perceptional aspect of our knowledge is such as to make it utterly impossible for the truly *same* characteristic to belong to more than one body. This fundamental truth has been overlooked in speculative biology largely, I suspect, from failure to note that so far as the subjective side of perception is concerned, "characteristic" is exactly synonymous with "quality" and "property." Bearing this fact in mind, the situation clears up readily when we turn to the familiar practical (not, generally, the theoretical) language of chemistry. The working chemist never for an instant thinks of trying to express or "explain" the characteristics, or properties of hydrogen in "terms of" the characteristics of oxygen, for he knows perfectly well that were he able to do such a thing there would be no such gas as hydrogen, for all hydrogen would be oxygen. There is no doubt in the world, as one sees if he looks at the case closely, that most of the recent effort to "explain" the adult organism in terms of the germ cells has involved just the self-destructive fallacy that the chemist would be a victim of were he to try to explain hydrogen in terms of oxygen. The fact that the adult organism develops from the germ cells while oxygen does not, so far as we know, develop from hydrogen, does not in the least affect the psychological fact that the adult is known by its own characteristics and in no other way, exactly as the germ cell is known by its characteristics and in no other way.

Once one sees clearly that this aspect of the problem of genetics differs *toto celo* from the problem of developmental potentiality, that is, the problem of how the germ cell is able to develop into the adult, he has gone a very long way toward a consistent, workable philosophy of biology.

In Jennings's sentence "if the phrase 'potential immortality' means anything for the infusorian, it means exactly the same for me, so far as we can judge from past history," I find encouragement for the hope that he will be willing to give my principle of standardization a good testing.

WM. E. RITTER

MARINE BIOLOGICAL STATION OF SAN DIEGO,
LA JOLLA, CALIFORNIA,
January 4, 1912

THE CHESTNUT TREE DISEASE

TO THE EDITOR OF SCIENCE: In connection with the chestnut tree disease mentioned in SCIENCE of December 29, 1911, and in preceding numbers, the writer calls attention to the hardy giant chinquapin (*Castanopsis Chrysophilla*) of the Pacific states. This may be a resistant species adaptable to the southern states. It occurs in two varieties, the one just mentioned and a dwarfed variety. The former reaches a height of 120 feet and has a diameter of from 8 to 10 feet; ordinarily from 40 to 55 feet in height and from 1 to 2 feet in diameter. Locality, near Willets in Mendocino County, Cal. The dwarfed form is abundant in the Cascade and Sierra Nevada and San Jacinto mountains from 2,000 to 9,000 feet. It is mostly of shrubby habit, but to all appearances identical with the giant chinquapin. This latter is a hardy and long-lived evergreen of stately and handsome

form. The timber is suitable for many purposes, saws readily, is fine grained and light brown. The burr and nut of both varieties are almost identical in size and appearance with the eastern chinquapin. They are difficult to obtain and are frequently attacked by a small whitish worm, the egg of which is deposited, as in the eastern chinquapin and chestnut, by a moth.

The writer suggests that the giant chinquapin be experimented with as a possible resistant species to reforest the eastern states devastated by the chestnut tree disease. The tree would probably stand the eastern conditions south of Maryland. The shrub is extremely hardy.

Marsden Manson

San Francisco, Cal.,
January 8, 1912

AN UNUSUAL EFFECT OF A LIGHTNING DISCHARGE

The following note made by the writer under date of July 18, 1911, may be of interest: On the land of J. M. Dunklee (of Hawes postoffice, Ark.), in the N.E. ¼ of the N.E. ¼ of Sec. 11, T. 2 S., R. 20 W., the lightning struck an oak tree (according to Mr. Dunklee three years ago), much shattering it. The tree stood near the top of a sandstone ridge. The discharge passed to the roots of the tree, then followed in the ground down the north slope, tearing out a trench in places 3 feet wide, and which must at first have been 2½ feet deep. At this time, the depth is 1½ feet. The discharge followed down the slope 50 feet, tearing up the sandstone and throwing one block that is estimated to weigh 1,200 pounds up into the air and out of the trench. At the lower end of the trench, the discharge apparently passed beneath the surface, along a bedding plane between the upturned layers of sandstone. There is no evidence of any fusion of the rocks or the soil.

A. H. Purdue

Fayetteville, Ark.,
January 10, 1912

"MISUSE OF THE TERM 'GENOTYPE'"

To the Editor of Science: If the distinguished students of genetics whose communications have recently appeared in your pages do not imagine that their work is of interest to biologists and naturalists at large, then one is entitled to question their claim to so much of your space. Let them, one might say, confine their "terminological inexactitudes" to their own technical periodicals. If, however, they believe, as I do, that their highly valuable work should appeal to all biologists, and that it has a particularly important bearing on the methods and conclusions of the systematist, then surely they should try to avoid the use of terms that are liable to mislead the general naturalist, and that sooner or later must clash with those of the taxonomic biologist. But assuming that they persist in acting as though their work were either unworthy of general attention or far above the heads of all outside their charmed circle, still may one not appeal to them to recognize that serious writers in Science are at any rate their scientific colleagues, and as such have a claim to be treated with ordinary courtesy? To state, after what has been written, that Dr. Johannsen is the "originator of the word genotype" is to give either the cut direct or the lie direct to a fellow-worker.

F. A. Bather

London, England,
January 17, 1912

SCIENTIFIC BOOKS

The Animals and Man. An Elementary Text-book of Zoology and Human Physiology. By Vernon Lyman Kellogg. New York, Henry Holt and Company. Pp. 495.

The present trend in high schools toward a combined course in human physiology and zoology is calling forth its inevitable train of new text-books, of which the present volume by Professor Kellogg is one. Knowing the writer's practise in text-book preparation and his wide experience as a teacher and a zoologist, one is justified in looking for something exceptional in this new effort, but the reviewer must confess to a feeling of disappointment on reading the book. It has the appearance of having been hastily constructed with a somewhat too liberal use of scissors and paste on

the author's earlier text-books. The section on human physiology (chapters XXI.–XXVIII.), by Miss McCracken, while interesting enough in itself as an abridged elementary account of human anatomy and physiology, stands almost wholly unrelated to the rest of the text. To the reviewer, the present need seems rather to be for a text-book of zoology so thoroughly permeated with physiological interpretations and applications that the zoology and physiology become a unit throughout the entire work. However, beyond the question of arrangement of material—a matter which will doubtless always remain largely one of individual opinion—the over-plentiful sprinkling of errors throughout the book lays it open to more serious criticism. For example, on page 32 in a description of the crayfish we read that "In the female the genital pores are in the basal segments of the next to the last pair of legs." On the same page *ligaments* are spoken of when *tendons* are meant, the digestive gland is described as yellow whereas it is characteristically reddish or greenish in color, and *four* pairs of ostia (a dorsal, two lateral and one ventral pair) opening into the heart are called for. On page 35 occurs a questionable usage of the term *ureters*. Again, in the light of recent investigations, we doubt if the statocyst of the crayfish is very generally "believed to be an auditory organ" (pp. 30, 74). On the same page one reads that "the longer pair of appendages are the antennæ and the sense of smell is believed to be located in the fine hair-like projections upon the joints." As a matter of fact, certain peculiar club-shaped organs on the outer ramus of the *antennules* have generally been considered the chief olfactory end-organs. Recent researches of Holmes and Homuth confirm this but show that other parts of the body (mouth parts, tip of chelipeds, inner ramus of antennules and the antennæ) are also sensitive to olfactory stimuli. On page 41 we find this astonishing statement in an account of conjugation in Paramœcia, "... part of the macronucleus and micronucleus of each passes over to the other, and the mixed elements fuse together to form a new macro- and micronucleus in each half." In view of the wonderfully adapted mechanism in the amphibian heart for keeping the "pure" and "impure" blood at least approximately separated, the statement regarding the ventricle of the toad (p. 23) that "here the pure and impure blood are mixed," might well be qualified somewhat. On pages 14 and 15 *quill feathers* and *contour feathers* are set apart as two contrasting groups. On page 47 occurs the statement that "in addition to the proteids protoplasm usually contains native albumins," etc.; native albumins, of course, being proteins. Throughout the book the word proteid is used instead of the preferable protein. On page 100, speaking of the pairs of legs, the statement is made that "the order of their appearance differs in the toad tadpole and the frog tadpole." One is led to suspect that the author had in mind rather anuran and urodele tadpoles respectively. On page 153 we are inaccurately informed that "hermit crabs all have the habit of carrying about with them, as a protective covering into which to withdraw, the spiral shell of some gastropod mollusc," and in the same paragraph, speaking of the abdomen of the hermit crab, occurs the statement that "it has on it no legs or appendages except a pair for the hindmost segment, which are modified into hooks for holding fast to the interior of the shell." As a matter of fact while generally absent from the right side of the abdomen (except on the sixth somite), the pleopods of the left side, though often much reduced, are present, and in the female are used for the attachment of the eggs. On page 154 in speaking of the acorn barnacles the "six calcareous plates" mentioned are characteristic of the family *Hexameridæ* only and not of all "acorn barnacles." On page 170 we are told that "the cuttlefishes and octopi have no foot," but on page 178 that "the decapods, as their name indicates, have ten feet or arms," etc. Aside from this contradiction in statement, the high school student might pertinently inquire what the

name *Cephalopoda* indicates. On page 191 it is stated that "nearly all the Chordata are marked by the presence, either in embryonic or larval stages only, or else persisting throughout life, of a number of slits or clefts in the walls of the pharynx which serve for breathing, and which are called gill-slits." Do not *all* Chordata have gill-clefts at some stage of their life history? Again, on page 201 one reads the too inclusive statement that "all batrachians breathe by means of gills for a longer or shorter time after birth." On page 256, hyenas are classified as *Felidæ*. On page 337 we are informed that muscles are the active organs of motion and locomotion in all animals.

In the physiological section there is an obvious attempt to "write down" to the audience and the result is frequently anything but happy. For instance one meets not infrequently with such apparently significant though actually meaningless statements as (p. 291) "the most necessary element in all the world is oxygen." On page 294 one encounters the rather astonishing bit of information that "muscle is largely a compound of sulphur and other elements." On page 316 we read that "it is the function of hæmoglobin to carry oxygen to the tissues and carbon dioxide from the tissues," a statement which, to say the least, is misleading, in that as regards carbon dioxide, the carrying power of hæmoglobin is at most of minor importance. On page 340 heart muscle is classified as non-striated. On page 291 we encounter the obscure and in part erroneous statement that "carbohydrates contain carbon, hydrogen and oxygen, the former predominating. Fats contain also chiefly oxygen, carbon and hydrogen, the latter predominating." On page 296 under "Tests for Proteids" what is probably the most universal and certain test of all, the biuret reaction, is omitted. On page 301 referring to alcohol we find this remarkable piece of information—remarkable both in point of fact and of rhetorical climax —"unlike other poisons its use establishes a craving or appetite for it which eventually weakens the will and is apt to lead to intoxication." How *unlike* cocaine, opium, morphine, etc., is it in this cumulative effect? On page 311 we learn that "the mesentery is fastened at the back to the spinal column." On page 363 instead of using axon and axis cylinder as synonymous terms the axis cylinder is spoken of as a central fiber of the axon. On page 317 the term *fibrin* is misused.

A careful reading of the text discloses a considerable number of little inaccuracies, mainly in the way of too inclusive statements, but space will not permit of specific citation. Some of these may perhaps be excusable on the basis of being well-nigh unavoidable in an elementary book where confusion of ideas must be avoided, but in not a few instances a single qualifying word would have set the matter right.

While the reviewer has found it necessary to devote most of his space to pointing out errors, he does not wish to leave the impression that the book is without merit. On the contrary, it has many excellencies. The subject-matter is well chosen, the general descriptive treatment is for the most part excellent and interestingly written and the text covers a wide range of timely topics in addition to the more formal zoological work.

M. F. Guyer

University of Wisconsin

A FEW BOOKS ON AERONAUTICS

A new science and a new industry, a new sport and a new mode of warfare have come upon us with such startling suddenness that many are clamoring to know how it all came about; while authors are tumbling over each other—many over the facts and even over their English too—in a mad rush to tell the story, the story of aeronautics that only a master can tell.

The following are a few of the 1911 versions of this story.

Aerial Locomotion. By E. H. Harper and Allen Ferguson. Cambridge University Press, XII., 164, price 1 shilling.

This little book is so clearly written that it

can be understood by the average boy, and yet it explains many facts that often are either wholly ignored or, for the average reader, told only in unintelligible symbols and signs.

For the non-mathematical reader, and for the man who does not care for a large volume on the subject, this probably is one of the best books available.

The Aeroplane. By T. O'B. HUBBARD, J. H. LEDEBOER and C. C. TURNER. Longmans, Green and Co., X., 127, price 2 shillings 6 pence.

There is an old proverb to the effect that "too many cooks spoil the broth," and it seems to be eminently applicable in the present case.

The first chapter deals with the properties of the air, and is so full of errors that it would take another chapter to correct them. A simple example will suffice:

> Now the density of water-vapor is 0.623 of that of air, and since air can contain a portion of water-vapor amounting to 3 per cent. of its volume, it is obvious that saturated air is lighter than dry air.

This statement would be pretty hard to beat in a contest for number of errors in a single sentence. One had as well say that since a sponge can contain water that therefore a saturated sponge is lighter than a dry one.

As a matter of fact moist air is lighter than dry air at the same temperature and pressure, but the authors have not explained the correct reason.

The rest of the book, after the first chapter, is fairly good for the popular reader and has the excellent feature of conspicuous division into topics, but it is marred here and there by the presentation of rough approximations in the guise of exact values.

Bird Flight as the Basis of Aviation. By OTTO LILIENTHAL. Longmans, Green and Co., XXIV., 142.

This of course is a translation of an old and well-known German book. But the translation was worth while, since it enables a larger number of persons to read for themselves Lilienthal's accounts of numerous experiments based upon careful studies of birds and their mode of flight. It is astonishing how many experiments he and his brother made, and what generally well-founded conclusions they reached. Otto Lilienthal was one of the enthusiastic pioneers in the experimental study of aviation and his work undoubtedly contributed materially to the final accomplishment of mechanical flight, albeit along lines different from those he believed the most practicable. He believed that nature's method is always the best method—forgetting, possibly, that the locomotive, though swifter than the greyhound, runs on wheels and not on legs—and so he strove to fly, as do the birds, with beating wings and soaring.

Soaring, at least, is greatly to be desired, and likely some day to be fully achieved, and so this book, by one of the most enthusiastic advocates of bird flight, still has a freshness about it and much of interest; in fact it is one of the few aviation classics.

Monoplanes and Biplanes. By G. C. LOENING. Munn and Co., New York, XIV., 331, price $2.50.

This book is not adapted to the taste of the general reader—it is neither poetry nor romance—but to the man who is seriously studying aeronautics and needs to know how the various types of aeroplanes are made it is well nigh invaluable.

It begins with a short but appreciative account of the work of Langley, Lilienthal and Chanute. This is followed by several excellent chapters on air resistances and air friction, with numerical examples applicable to aeroplane designing.

After this, various types of aeroplanes, 18 monoplanes and 20 biplanes, are described in detail and intercompared. A separate chapter is devoted to the different types of controlling apparatus, and another timely and sensible chapter, to accidents and their various causes.

Every chapter is profusely illustrated, and in the great majority of cases the illustrations are extremely helpful to the reader. There also are numerous references to original articles which may be consulted by those who wish more detailed information.

In a new edition pages 18, 19 and 20, in so far as they discuss air density, might be slightly modified to advantage. Here "air holes" are spoken of as places of low air density.

An aeroplane entering one of these low density regions from the air of higher density around it, will suddenly fall without any warning, merely because the pressure has enormously decreased, and the aeroplane has not had time to attain the requisite velocity of support in this lighter medium.

Enormous differences in pressure must cause enormous changes in the barometer, but such sudden changes are never found in the open, and, besides, it can be shown that the movement (whirl) of the atmosphere necessary to produce a change of pressure amounting to one tenth of the total would be of most destructive violence.

But this is a small fault to find with a book so generally helpful.

Elementary Aeronautics. By ALBERT P. THURSTON. Whittaker and Co., 126.

This is a non-mathematical but clearly written account of the action of air upon moving surfaces, plane and curved, and the application of these principles in the design and operation of aeroplanes.

While both elementary and brief, it seems to be free from errors, and can be recommended to those who wish some reliable information about the general action of aeroplanes, but have not the time to make a real study of them.

W. J. HUMPHREYS

A Manual of Philippine Silk Culture. By CHARLES S. BANKS, Department of the Interior, Bureau of Science, Manila, 1911.

Mr. Banks has been engaged, among his other duties, in a study of the possibilities in the way of profitable silk culture in the Philippines ever since the Bureau of Science was started, and this manual puts into convenient shape the results of his investigations. It is a royal octavo pamphlet of about fifty pages, with 18 good halftone plates and diagrams of rearing house and reel. He gives directions for the care of the domestic mulberry silkworm, and announces a cross between the Bengal-Ceylon and Japanese silkworms which he terms "the Philippine race of silkworms." He also announces the successful introduction of the Eri or Castor silkworm (*Attacus ricini* Boisd.) from Ceylon. He thinks that the silk produced from this insect will be popular not only among the Christian Filipinos, but also among the mountain tribes and the Moros, and further that it will find a sale among the Americans and Europeans for hangings, upholstery and even for heavy dress goods. He concludes that, with both the mulberry and the Eri silkworms, the industry can be carried on in the Philippines under conditions as favorable as those which obtain in the best silk-producing countries in the world, with the added advantage that no disease has appeared as yet. That every effort is being made to prevent the introduction of disease is shown by the act of August 14, 1907, prohibiting the importation of silkworms, either eggs or cocoons, into the Philippine Islands except by the Bureau of Science.

L. O. H.

SPECIAL ARTICLES

FOSSIL HOLOTHURIANS

FEW classes of animals have a less satisfactory geological record than the holothurians and every fragment that can be gathered is therefore of unusual interest and importance. The known records occur in two forms, impressions of the whole animal or much more commonly, nearly or quite microscopic calcareous particles imbedded in fine shales and limestones and resembling more or less nearly the similar calcareous particles found in the body-wall of most living holothurians. Ludwig[1] has well summed up the phylogenetic value of these fossil particles:

Solche Reste aus dem Kohlenkalk, dem Jura, der Kreide und dem Tertiär vorliegen, aber keine sichere Bestimmung nach Art, Gattung und Familie gestatten: nur die eocänen Synaptidenreste . . . machen davon eine Ausnahme, da sie sich mit einiger Sicherheit auf die Gattungen Synapta, Chiridota (oder Trochodota) und Myriotrochus beziehen lassen.

[1] 1892, "Die Seewalzen," p. 446.

If then we are to secure satisfactory paleontological knowledge of the history of holothurians we must look for it in the impressions (or possibly casts) of the entire animal. As yet evidence of this sort is very rare and highly unsatisfactory. Rüppell[2] long ago described what he thought was a fossil holothurian from the Solenhofen limestone but there is little about either his description or figure that warrants his conclusion. Zittel[3] suggested that the object might perhaps be a cephalopod, but that is also little more than a guess. Giebel[4] has given an account, accompanied by three good figures, of fossils from the same limestones for which he proposed a genus "Protholoturia." Zittel (*l. c.*) refers casually to this genus but considers the specimens "problematische körper." Probably he was not familiar with the appearance of living holothurians, particularly when eviscerating; otherwise it is hard to see why he was so doubtful about Giebel's specimens. Ludwig (*l. c.*) quotes Zittel but apparently without having examined Giebel's figures, which are deserving of careful consideration. Study of these figures and their accompanying text has satisfied me that the objects really are the impressions or casts of holothurians. Giebel found calcareous particles in the outer body layer (or on the surface of the object), thus confirming the impression made by the striking resemblance of the outline and surface, to contracted specimens of the smaller species of Holothuria. It seems to be impossible, however, to point out any characters by which "Protholoturia" may be distinguished from Holothuria and the name is no doubt a synonym, but it is odd that it is not listed in Scudder's Index (either as Protholoturia, Proholothuria or Protoholothuria) nor in the later generic lists of the "Zoological Record." Even Spandel and other writers on fossil holothurian remains seem to have overlooked or forgotten Giebel's work. Simonelli[5] figures a peculiar fossil, *Lorenzinia*, which he suggests may be part of a holothurian allied to *Pelagothuria*. The material is such that no real identification is possible and the probability of its having anything to do with holothurians is very remote.

The Solenhofen specimens of Giebel therefore appear to be the only fossil holothurians known (not counting, of course, isolated calcareous particles) and obviously their phylogenetic value is slight, as they simply show that holothurians apparently like those of the present day existed in the Jurassic Seas. It was, therefore, a matter of extraordinary interest when Dr. Walcott recently announced the discovery of a notably diversified holothurian fauna in the Middle Cambrian rocks of British Columbia.[6] Through the greatly appreciated courtesy of Dr. Walcott and the kindly assistance of Mr. Austin H. Clark, I have recently had the privilege of examining the material upon which this report is based and I will say at once that Dr. Walcott's published figures leave almost nothing to be desired. Excepting only two specimens, examination of the originals showed nothing not revealed by the figures and equally important is the fact that the figures show nothing which is not equally distinct in the specimens. This is most satisfactory, as it will enable any one familiar with the fundamental characteristics of the class to form an intelligent opinion as to whether Dr. Walcott's fossils represent holothurians or not. The two cases in which I have taken exception to the figures are found on plates ten and thirteen. In Figure 1, Plate 10, the illustration does not quite do justice to the specimen; the knobs shown above the central ring (*CR*) are more distinct in the specimen, two of them showing not only definite outlines but some indications of their structure. In Figure 2, Plate 13, on the other hand, the terminal mouth

[2] 1829, "Abbildung und Beschreibung einiger . . . Versteinerungen . . . von Solenhofen."

[3] 1876–80, "Handbuch der Paläontologie," Bd. 1, Abt. 1.

[4] 1857, *Zeitsch. f. die Gesammten Naturw.*, Bd. IX., pp. 385–388.

[5] 1906, *Bologna Mem. Acc. Sc.*, 1905, series 6, Vol. 2, pp. 263–268.

[6] 1911, "Cambrian Geology and Palæontology," II., No. 3, Middle Cambrian Holothurians and Medusæ, *Smithsonian Misc. Coll.*, Vol. 57, No. 3.

surrounded by a jointed or notched ring is distinctly shown; in the specimen, I was unable to make out these points satisfactorily; there seems little doubt about the terminal mouth, but the surrounding ring is ill-defined and I failed to see the joints.

Dr. Walcott names and describes four genera, each with a single species, of what he believes to be holothurians. He apparently has not seen Giebel's figures for he says (p. 42) that his specimens record "for the first time, with the exception of some scattered calcareous spicules and plates, the presence of this class of organisms in any geological formation." That he feels no serious doubts as to the fossils being holothurians is shown by the statement (p. 43) that they establish "the very ancient origin of the Class Holothurioidea and the fact of its great differentiation in Middle Cambrian time," and the assertion (p. 45) that "The Holothuriidæ is represented by *Laggania cambria* and *Louisella pedunculata* and the Synaptidæ by *Mackenzia costalis*. The Pelagothuridæ is indirectly represented by *Eldonia ludwigi*." It is not clear what is meant by the Pelagothuriidæ being "indirectly represented" by *Eldonia* since that genus is subsequently made the foundation of a new family, the Eldoniidæ, especially as Dr. Walcott later shows that his new genus has almost nothing in common with Pelagothuria.

The material upon which *Eldonia* is based is abundant and much of it seems to be very well preserved, but of *Laggania* and *Louisella* there are single specimens only, while of *Mackenzia* there are but two specimens and they differ from each other greatly. Of *Laggania*, Dr. Walcott says the mouth was "ventral, near the anterior end and surrounded by a ring of plates." "It is not practicable to make out the arrangement of the plate-like structure surrounding the mouth, as the calcareous plates, if ever present, have disappeared." "Traces of tube-feet occur on the ventral surface" but "the body of the animal is so completely flattened that the tube-feet are obscured." I have sought in vain both in the figure and on the specimen for anything that could be called a tube-foot, without an excessive use of the imagination. Moreover the "ring of plates" surrounding the mouth does not remind one of the calcareous ring of a holothurian, but it does suggest to me the radiating folds surrounding the partially contracted oral disk of certain actinians and worms. Dr. Walcott calls attention to the surface markings of "indistinct concentric bands, each one of which is crossed by fine longitudinal lines." This can be easily seen in the figure (at least in certain spots) with the aid of a lens. I do not recall any holothurian with such a surface, but it is suggestive of certain worms, and even some actinians have a somewhat similar exterior. On the whole it does not seem to me that *Laggania* can be positively assigned to any invertebrate phylum. I see nothing beyond the probable form of the body, and the terminal mouth, to suggest a holothurian, and these characters are equally suggestive of actinians.

The specimen of *Louisella* seems to show more structure and Dr. Walcott says of it:

With numerous tube-feet or podia in two longitudinal rows, and what may be papillæ on two peltate extensions at the posterior end. . . . The ventral sole is beautifully outlined by the marginal row of podia on each side.

Examination of the specimen (or figure) shows of course what Dr. Walcott has called the "ventral sole" and "marginal rows of podia," but neither is suggestive of any known holothurian excepting some of the bizarre Elasipod forms like *Scotoplanes*, to which Dr. Wolcott refers. None of the podia are sufficiently defined to enable one to make out even the form, let alone the structure, whereas if they were really like those of *Scotoplanes* and other Elasipods, their rigidity would have caused them to be as well defined as any part of the body-outline. Dr. Walcott considers *Louisella* a genus of the Holothuriidæ, but the size and arrangement of the supposed podia are entirely unlike anything known in that family. If *Louisella* is a holothurian at all, its "ventral sole" and big podia (?) would suggest the Elasipods as its nearest allies, and the two extensions of the posterior end might be considered confirm-

atory evidence. But as there seems to be no really characteristic holothurian structure shown by the fossil, I fail to see why it should be considered a holothurian.

The small specimen of *Mackenzia* is very suggestive of a synaptid without its tentacles, but the most searching examination fails to show a single character which gives positive support to this view. The mouth and its associated structures are not distinctly indicated. As stated above, I could not distinguish any separated or definite parts in the raised ring which seems to surround the mouth, and there is nothing in it to me suggestive of the calcareous ring of a synaptid. The longitudinal markings of the body-wall are more numerous and closer together than they should be if they indicate the longitudinal muscles of a holothurian. On the whole, these longitudinal markings, the appearance of the body surface and of the oral end, and the form of the animal all seem to me suggestive of certain actinians, although I do not assert that the fossil really represents that group. The larger specimen, referred to *Mackenzia* by Dr. Walcott, shows practically no structure and in my judgment can not be assigned positively to that or any other genus.

Turning now to *Eldonia*, of which the material is plentiful and its condition such that the structure can be made out with a fair degree of completeness, we find an animal so medusoid in outer form that Dr. Walcott uses the terms "exumbrella," "subumbrella," "lobation" and "lappets" and says "the system of radial canals is very striking and medusalike." I do not recall any medusa with a canal system like *Eldonia's*, with a small central ring, but I think most of us will agree that the general appearance of the animal is that of a free-swimming Cœlenterate, except for the apparently distinct and extraordinary alimentary canal. It is upon the interpretation given this structure and upon the importance attached to it, that our final decision as to the position of *Eldonia* must depend. Dr. Walcott at first thought it might be a commensal worm but later decided it was really the alimentary canal of the animal itself, and upon the strength of its partially spiral form, he based his decision to call *Eldonia* a holothurian. He has, however, pointed out the essential differences between *Eldonia* and *Pelagothuria*, the only known free-swimming holothurian, making it plain that they are not at all nearly allied. Emphasis should be placed on the fact that except for the expansion of the oral disk as a swimming organ, *Pelagothuria* is not an extraordinary holothurian, its internal anatomy being like that of many other members of the class. Its alimentary canal is in loops (a long drawn out spiral) and the mouth is surrounded by the usual circle of tentacles. The alimentary canal of *Eldonia* is not in loops as in a holothurian but seems to have been more nearly in a single plane like one half of the canal of a sea-urchin. The appearance of the tube thus seems to me more echinoid than holothurioid. The mouth of *Eldonia* has on either side a large tentacle; neither Dr. Walcott nor I have been able to find more than two and the whole appearance of the oral region indicates two as the normal number. The tentacles are described by Dr. Walcott as "peltato-digitate" but they have almost nothing in common with the sort of tentacles to which that term has hitherto been applied.[7] On the other hand they seem to me suggestive of the marginal clusters of tentacles in *Lucernaria* and its allies. Perhaps even the oral tentacles of some Rhizostomous Medusæ are not fundamentally different. In some of the specimens, notably the one shown in Fig. 1, Pl. 10, bits of the tentacles show some slight indications of their finer structure. In the figure referred to, small lobes or knobs above the central ring (*CR*) are noticeable and these, in the specimen, show, under the lens, a remarkable resemblance to clusters of nettle-cells. I am not sure that these lobes are part of the tentacles but if they are, as they seem to be, my opinion that the tentacles are more medusoid than like anything known among holothurians would be confirmed. *Eldonia* shows absolutely no trace of pen-

[7] See Ludwig, 1892, "Die Seewalzen," p. 97; Pl. VII., Fig. 5.

tamerous symmetry, no trace of calcareous structure, no longitudinal muscles and no podia. The radial canal system is utterly unlike the water-vascular system of any known Echinoderm and it is perfectly inconceivable how the fundamental, circumoral ring of a holothurian could disengage itself from the esophagus and migrate to the opposite end of the body.

If *Eldonia* is a holothurian, it becomes virtually impossible to define the class, except in terms of the alimentary canal. Indeed if *Eldonia* is a holothurian, the Echinoderms themselves can be defined in no other terms, for *Eldonia* lacks every single character which justifies the customary view that holothurians are Echinoderms. It is far less of a strain on my credulity to believe that *Eldonia*, whose extraordinary nature I have no inclination to deny, is some sort of a Cœlenterate with a commensal worm inside or under the subumbrella, or even that it represents a hitherto unknown phylum, than to believe that it is a holothurian or is connected, save in the remotest way, with the Echinoderms.

As a final result of my examination of the evidence, I am forced to conclude that there is no sufficient justification for the belief in a Cambrian holothurian fauna. The external form of *Louisella* and *Mackenzia* and the supposed alimentary canal of *Eldonia* can not be considered adequate basis for such a belief. There is no good evidence, either in Dr. Walcott's material or elsewhere, to show that holothurians existed before the Carboniferous. But as wheels, which are certainly of a Chiridota-like form, occur in the Zechstein of Europe, and animals closely allied to our modern Holothuria are found in the Solenhofen limestone, it is not improbable that the holothurians were differentiated about as early as the other classes of Echinoderms, excepting the Pelmatozoa. Evidence however in support of such a probability is still conspicuous by its absence.

Hubert Lyman Clark
Museum of Comparative Zoology,
Cambridge, Mass.,
January 12, 1912

BIOLOGY OF MIASTOR AND OLIGARCES

The general availability of *Miastor*, at least for laboratory work, justifies the following summary account of the biology of this interesting form and the allied, possibly sometimes associated, *Oligarces.*

Distribution.—*Miastor* is probably worldwide in distribution, having been recorded from Europe, Australia, North and South America. We have found this genus ranging in New York from the upper austral Hudson valley to the transition or boreal Adirondack region. These peculiar larvæ have also been found in Connecticut and Indiana.

Oligarces has been recorded only from Europe and North America, Albany and adjacent Nassau, N. Y., being the only American localities at present known. This species is probably widely distributed though presumably rarer or less easily detected.

Larval Habits.—The moist inner bark of various trees in the incipient stages of decay are likely places for *Miastor* larvæ. Chestnut rails, ties, stumps, the moist bark of maple, oak, birch, beech and hickory indicate no closely restricted food habits. In addition to some of the above, European report *Miastor* larvæ from elm, ash, ironwood and sugar-beet residue.

We have found *Oligarces* only in decaying elm bark, possibly because the larvæ are not so readily detected in nature.

Distinguishing Characters.—Large colonies of *Miastor* larvæ are easily recognized by the masses of more or less adherent yellowish or whitish larvæ, and especially by the occurrence here and there of motionless individuals with poorly indicated segmentation and elongate, transparent areas, the developing embryos, or containing young so well developed as to be easily distinguished with a hand magnifier, even the form of the head and the fuscous ocular spot being visible. The head of these larvæ, whether small or large, is flattened, triangular with diverging antennæ and quite different from the strongly convex, usually fuscous head of *Sciara* larvæ. *Miastor* larvæ have transverse incisurial bands of

chitinous spines, best developed on the anterior body segments. These larvæ are $\frac{1}{20}$ to $\frac{1}{8}$ of an inch long and may occur in small clusters in the bark or form dense masses covering several, if not a number of square inches, frequently more or less clustered and appearing much like a mass of fungous matter, commonly seen under bark.

Oligarces larvæ are similar in general aspects, though we have yet to find them in any such large masses as described above. Elm bark containing this maggot gives little evidence on the inner surface of their presence, since these larvæ appear to confine themselves mostly to the interstices of the bark.

Biology.—The larvæ of both genera reproduce by pedogenesis in the fall and early spring. We have also observed this in the case of *Miastor* in midsummer. Moisture and moderately cool weather appear to be especially favorable. With these conditions we are inclined to believe that pedogenesis may continue indefinitely, since we have kept larvæ healthy and multiplying for nearly six months with nothing more elaborate than a moist piece of decaying wood clamped lightly to an ordinary microscopic slide. A larval generation appears to occupy about 3 to $3\frac{1}{2}$ weeks, though it is evident that much depends upon moisture, food and temperature. We were fortunate in the case of two larvæ to witness the development of the egg in the ovary, its gradual separation therefrom by fission and the growth to an individual nearly ready to escape from the mother larva. This entire process occupied about three weeks. The development of the embryo is at the expense of the mother, the young absorbing their nourishment from her. Pulsations in the mother larva continue so long as a fragment of the dorsal vessel remains; in one specimen observed the dorsal vessel of the mother larva was ruptured in the vicinity of the sixth body segment and the free anterior portion continued violent pulsations and irregular wrigglings till the next day, at which time the movements were much slower and by the following day had disappeared entirely.

Reproduction by pedogenesis continues in the spring till just before the final changes to the adult, the larval colonies displaying a marked tendency to arrange themselves in groups and occasionally form rather striking combinations. This occurs, even in the case of colonies established under artificial conditions. At this season at least there is a marked tendency toward uniformity in the production of larval generations, a considerable proportion of the larva in any one colony containing embryos which may escape at about the same time and migrate to another location before establishing themselves. This removal from the exuviæ of an earlier generation clearly indicates a phytophagic habit and is presumably of value in avoiding natural enemies. In early May, 1911, embryos escaped in large numbers from mother larvæ, established a colony and in a few days showed a well-developed breastbone. The transformation to the prepupa, characterized by a marked swelling and transparent condition of the anterior body segments of the larva, occurred shortly, they remained in this condition two to three days and then changed to the pupa, a stage lasting about six days. These small midges appeared in enormous numbers in our breeding jars during the late morning hours, namely, from about 9 A.M. until noon, the midges swarming over the sides of the jar and behaving much like minute ants. There is comparatively little tendency to take wing. This may continue for several days and the midges may appear in smaller numbers for a period of several weeks. Larvæ collected in the Adirondacks did not produce midges till in early August. There was a marked preponderance of one sex in rearings from a breeding jar one day, followed by an approximate reversal subsequently. This was not sufficiently marked so that we felt justified in attempting to deduce any general rule. The abdomen of the female contains four to six large eggs, each nearly as long as the abdomen. They appear to be well developed and are probably deposited shortly after the appearance of the midges and the pedogenetic generations commenced wherever conditions are favorable.

Oligarces behaves somewhat differently. A number of larvæ, probably mostly mother larvæ, containing embryos were found in elm bark March 18, 1911. This material was kept in a warm room, and a week later the interior of the jars literally swarmed with thousands of active, whitish maggots with here and there a yellowish or yellowish-transparent one. Many of these perished upon the walls of the jar, and even those confined between a piece of glass and decaying elm bark soon succumbed. In spite of this a pupa was found April 19 and adults obtained about a week later. These small, white larvæ mentioned above differed from typical *Miastor* larvæ and some, at least, evidently established themselves in the crevices of the bark, transforming to pupæ, and these in turn worked out to the free surface a day or so before the disclosure of the imago. These pupæ appeared to move more readily than those of *Miastor,* and in several instances were observed standing upon the moist surface of the bark, supported only by the somewhat mucilaginous posterior extremity.

Natural Enemies.—Both *Miastor* and *Oligarces* larvæ are subject to attack by several predaceous Dipterous larvæ occurring in similar situations. The pinkish larvæ of *Lestodiplosis,* resembling in a general way those of *Miastor* except for a difference in color and more slender structure, may be seen here and there among their prey, and in the case of populous clusters of white *Miastor* larvæ, may give an ornamental touch to the colony. *Itonida pugionis* Felt may also prey on *Miastor.* Two larger predaceous maggots, those of *Lonchæa polita* Loew and a species of *Medeterus* are commonly found in the vicinity of *Miastor* colonies, and it not infrequently happens that they are the only available evidence of the earlier occurrence of *Miastor.* The larvæ of these two latter are voracious forms and are undoubtedly responsible for the speedy destruction of many *Miastor* colonies. The finding of these predaceous larvæ may serve as a guide to the searcher for *Miastor* and suggests investigating the more inaccessible portions of the bark for colonies which may have escaped the predaceous maggots.

E. P. Felt

SPURRED FLOWERS IN CALCEOLARIA

The *genus Calceolaria,* often popularly called slipperwort, belongs to the Scrophulariaceæ. It may be divided into two sections; first, the herbaceous kind, the one usually employed by florists in this country; second, the shrubby and bedding kinds.

The herbaceous kinds are grown from seeds. When well grown they are very ornamental and serve to decorate the greenhouse in spring, when other plants are through blooming.

The shrubby kinds are serviceable to some extent for indoor decoration. They are extensively grown in Britain for bedding purposes. Owing to the American summers being so hot, they are unsuited for bedding purposes here. They are mostly raised from cuttings.

A little more than a year ago some crossing experiments were conducted by a student in one of the regular undergraduate courses, No. 6, in the department of botany. This course was in charge of Professor Geo. F. Atkinson and Mr. Robert Shore, the head gardener of the department. The student, Miss Margaret C. Graham, performed the experiments under the supervision of Mr. Shore. Since, in public lectures, several unauthorized references have been made to these spurred calceolarias, it seems desirable to place on record the principal facts in connection with the experiments, and to state that the work is still in progress by Professor Atkinson and Mr. Shore.

A shrubby plant was crossed with a herbaceous one. This gave plants of a stronger growth, more profuse bloomers, more compact and more ornamental. Some of these varieties can be propagated from cuttings. These hybrids have been recrossed and the offspring have produced an interesting variety in habit of plants and variation of flowers. Some of the varieties have a number of spurred flowers, one or two spurs on the labellum. These spurred varieties have been cross pollinated and self pollinated, and varieties raised from these seeds have produced several spurred flowers.

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